

INL Assessment of PNNL Water Conservation Study for the ATR Complex

August 2013



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**INL Assessment of
PNNL Water Conservation Study
for the ATR Complex**

August 2013

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Idaho Falls, Idaho 83415
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**Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517**

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INL/EXT-13-29045

August 2013

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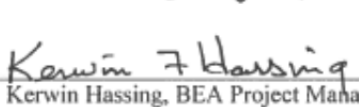
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ABSTRACT

This report documents an assessment of water conservation measures proposed for the Idaho National Laboratory's Advance Test Reactor Complex. Four of these measures were identified by Pacific Northwest National Laboratory in April 2012 and evaluated for potential water savings, energy savings, and implementation costs. Six additional measures were identified and evaluated by the Idaho National Laboratory. The original water assessment conducted by Pacific Northwest National Laboratory was sponsored by the U.S. Department of Energy Sustainability Performance Office to support implementation of the Department of Energy's Strategic Sustainability Performance Plan.

This assessment summarizes the four Pacific Northwest National Laboratory proposed water conservation measures, Idaho National Laboratory reviews and technical evaluations of those measures, and an evaluation of the six additional proposed measures. Each proposal was evaluated in terms of water savings, feasibility, implementation, and cost. Based on review of the PNNL assessment, it is recommended the four PNNL proposals not be implemented at this time due to operational and technical concerns, and excessive cost. INL recommends two of the six additional proposed measures be implemented immediately. These two options alone will result in nearly 55 million gallons of reduced water use annually at no additional cost. It is recommended that other INL measures be implemented as funding and project prioritization allow.

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ACRONYMS

ATR	Advanced Test Reactor
CEDR	Consolidated Energy Data Report
CFA	Central Facilities Area
CFM	cubic feet per minute
COC	Cycles of Concentration
CWP	Cold Waste Pond
DOE	Department of Energy
DOE-ID	Department of Energy – Idaho
EO	Executive Order
ft	feet
gpm	gallons per minute
gpy	gallons per year
HEDP	hydroxyethylidene diphosphonic acid
HVAC	heating, ventilation, and air conditioning
IA	Instrument Air
IDAPA	Idaho Administrative Procedures Act
l	liter
IDEQ	Idaho Department of Environmental Quality
INL	Idaho National Laboratory
in	inch
IWRP	Industrial Wastewater Reuse Permit
K	thousand
M	million
MCM	Mixing Cell Model
MFC	Materials and Fuels Complex
mg	milligrams
PA	Plant Air
PBTC	phosphonobutane-tricarboxylic acid
PCS	Primary Coolant System
PEMP	Performance Evaluation Measurement Plan
PO ₄	Phosphate
PNNL	Pacific Northwest National Laboratory
PPM	parts per million

SCS	Secondary Coolant System
SPO	Sustainability Performance Office
SSPP	Strategic Sustainability Performance Plan
TDS	total dissolved solids
TRA	Test Reactor Area
UCW	Utility Cooling Water
WHRS	Waste Heat Recovery System

INL Assessment of PNNL Water Conservation Study for the ATR Complex

1. INTRODUCTION

To support the implementation of the U.S. Department of Energy (DOE) Strategic Sustainability Performance Plan (SSPP), the DOE Sustainability Performance Office (SPO) sponsored three comprehensive water assessments performed by Pacific Northwest National Laboratory (PNNL) in their 2012 report. As DOE's third largest water user, Idaho National Laboratory (INL) was one of the selected assessment sites. Driven by DOE SSPP water conservation goals, Executive Order (EO) 13514, *Federal Leadership in Environmental, Energy and Economic Performance*, and the facility water evaluation requirement of Section 432 of the Energy Independence and Security Act of 2007, the objectives of the PNNL water assessment were to:

- Develop a comprehensive understanding of current water-consuming activities and equipment at INL
- Identify water efficiency improvements
- Provide best practices replicable at other DOE facilities.

The INL Site covers 890 square miles in southeastern Idaho. The main campus, located in Idaho Falls, is called the Research and Education Campus. User facilities at the INL Site include the Advanced Test Reactor (ATR) Complex, Central Facilities Area (CFA), and Materials and Fuels Complex (MFC). Additional facilities at INL include the Radioactive Waste Management Complex, Specific Manufacturing Capability, and Naval Reactors Facility, though not all of these are under the purview of the DOE-Idaho Operations Office (DOE-ID). The primary focus of this report is the known significant users of water at INL. While the PNNL assessment team did survey buildings at the Idaho Falls campus, INL's main priority and the focus of the assessment was the ATR Complex because it consumes over 50% of the water at INL and previous water projects have not concentrated on the ATR Complex. Reference the INL 2012 annual Consolidated Energy Data Report.

The ATR Complex is located on approximately 100 acres in the southwestern portion of the INL Site, approximately 47 miles west of Idaho Falls, Idaho, in Butte County. The ATR Complex consists of buildings and structures used to conduct research associated with developing, testing, and analyzing materials used in nuclear and reactor applications and both radiological and non-radiological laboratory analyses.

2. SCOPE

The scope of this assessment is to estimate water and economic savings of proposed water conservation measures, identify the feasibility of each measure, identify requirements and activities for implementing the measures, estimate costs for the measures, and provide a recommendation of most promising measures for implementation. For this water use assessment, ten measures were assessed. The four measures originally assessed by PNNL are:

1. Utilize Cooling Tower Blowdown Control
2. Replace Inorganic PO₄ Scale/Corrosion Control Chemistry
3. Auxiliary Cooling Water Supply to ATR heating, ventilation, and air conditioning (HVAC) during Outages
4. Dry-Fluid Cooling to Replace Once-Through Air Compressor.

The six additional measures identified by INL are:

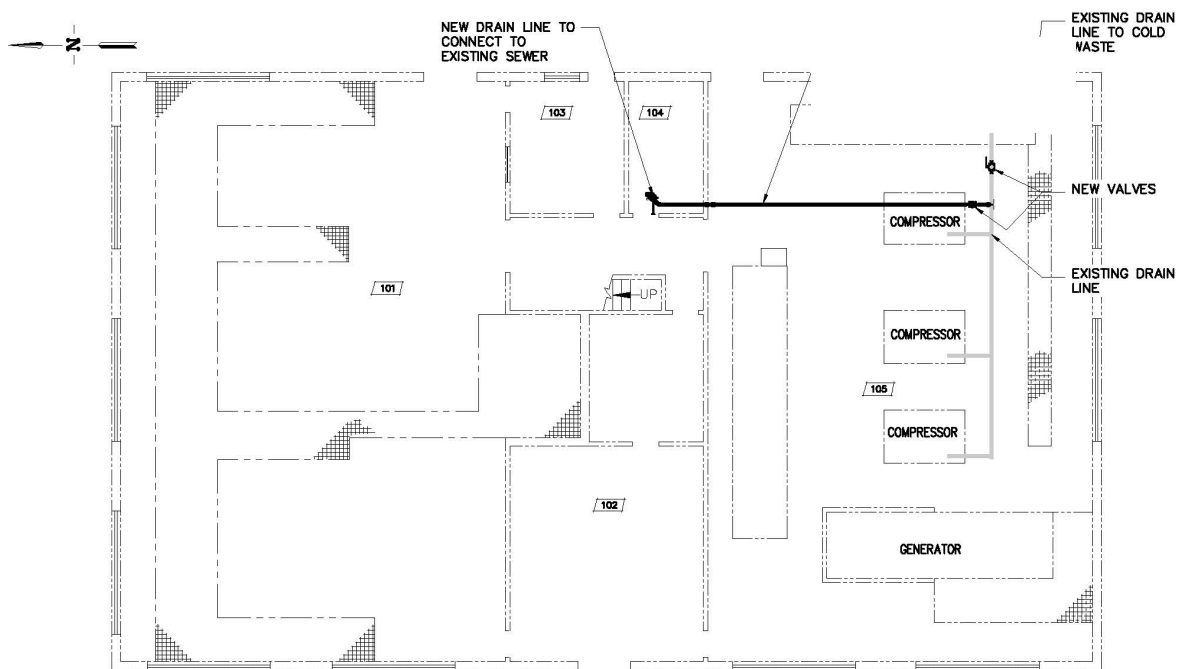
1. ATR Sewage Lagoon Options
2. Test Reactor Area (TRA)-609 Air Compressor Cooling Water Discharge
3. TRA-628 HVAC Control System Modification
4. ATR Cold Waste Pond (CWP) Evaluation
5. Reduce Desert Purge Flow Rate
6. Xeriscape Installation at the ATR Complex.

3. UTILIZE COOLING TOWER BLOWDOWN CONTROL

PNNL Recommendation 1

3.1 Description

The ATR Secondary Coolant System (SCS) provides cooling water to the ATR primary cooling system. The Utility Cooling Water (UCW) System provides cooling to ATR support equipment. Each system has a circulating pump, but utilizes common header piping into and out of the cooling tower. This secondary cooling loop is an open-loop recirculated system, with water circulating via the SCS and UCW cooling water pumps. The ATR SCS delivers cooling water to the ATR primary heat exchangers and then back to the cooling tower. The UCW system delivers cooling water to support equipment, such as the diesel generators, and then back to the cooling tower. The water is distributed over the film fill of the cooling tower. The cooling tower has fans pulling air upward through the film fill as the water falls through. The air flowing over the water is the mechanism used to extract the heat from the water prior to the water reentering the basin. In this process, a portion of the water is lost to evaporation. The evaporation yields an increase of dissolved solids in the remaining water. ATR currently utilizes a continuous blowdown method to maintain total dissolved solids (TDS) and conductivity within the limits prescribed in ATR Complex Plant Water Chemistry Operating and Maintenance Manual. The blowdown is a discharge of higher TDS and conductivity water to the cold waste system. The evaporated water and blowdown is replaced with raw water (untreated well water) from the ATR raw water system. The cooling water reenters the basin after passing through the cooling tower. Refer to Figure 1 for a flow diagram illustrating the SCS and UCW System.



TRA-609 PLAN

Figure 1. Secondary/UCW system flow diagram.

3.2 PNNL Recommendation

The PNNL study proposes replacing the existing continuous blowdown with an automated system in conjunction with changes to the current water chemistry control system. The automated system performs the blowdown periodically based on water chemistry. Blowdown or chemical feed occurs as the water chemistry levels reach the upper or lower limits. PNNL projected a water savings of 6 M gallons per year (gpy) that would yield an energy savings of \$700 per year.

3.3 INL Evaluation

There are several issues associated with moving to an automated system and changing the water chemistry control system. First, the PNNL study did not include the full scope of work necessary to implement an automated system. The automated system would require engineering design, configuration control work, piping modifications, software modifications, procedure updates, and training for all operators and other affected personnel.

Second, chemistry control is the key to continuous operation of the test reactor. The ATR secondary cooling system is using the original, 50-year-old piping installed in the mid to late 1960s. The bulk of the components in the system are original to the plant, including the primary heat exchangers. Age and use have naturally deteriorated many of these older components, particularly with regard to corrosion. Changes to the chemistry control, if not properly analyzed and studied, could have detrimental effects on the components in the system, resulting in extended down time and costly repairs. In this time of reduced funding, it would be difficult to obtain the necessary money to replace the heat exchangers or other large components in the secondary cooling system. The current chemistry control process is known and has proven to maintain low corrosion rates in the system. Any perturbations to the system would need to be very carefully studied and analyzed.

3.4 Implementation Cost

3.4.1 PNNL Cost Estimate

The PNNL study identified the cost to install the blowdown control system at \$5,700.

3.4.2 INL Cost Estimate

The cost estimate developed by INL for this PNNL proposed measure is solely to perform a detailed analysis to determine the potential use of an automated system. It does not include the cost to implement PNNL's recommendation. An implementation cost estimate will be developed by the INL if the evaluation is performed and a determination is made to implement an automated system. This preliminary cost estimate provided a range of:

- A low end value of \$72,000
- A targeted point value of \$90,000
- A high end value of \$117,000

See Attachment 1, "ATR Water Study – INL Cost Estimate: Utilize Cooling Tower Blowdown Control," for a summary level report of the target point value. A detailed cost estimate will be required to obtain funding if it is decided to implement this proposed measure.

3.5 INL Recommendation

Any changes to the chemistry and control of the ATR secondary cooling system must be very carefully considered. The PNNL study does not explore the full implications of the proposed changes, and only focuses on the potential water savings, giving no consideration to the full impact of the change. Further study is necessary to determine feasibility of the addition of an automated blowdown control.

Reactor safety, reliability, and operational impacts preclude any upgrades to this system. INL will consider evaluating the potential use of an automated system if funds become available. A full chemistry analysis would be performed as part of the study. The risk associated with changing water chemistry without a full analysis and installing an automated system on an aged system currently exceeds the acceptable operating parameters at ATR.

4. REPLACE INORGANIC PO₄ SCALE/CORROSION CONTROL CHEMISTRY

PNNL Recommendation 2

4.1 Description

Ortho-phosphate is a well-tested chemical and has historically been used in recirculating cooling water for corrosion control of carbon steel systems. As an anodic inhibitor, it is generally effective in the presence of oxygen and a pH greater than 7.5. Treatment levels commonly range from 10–20 ppm as PO₄ at a neutral pH (7.0), and decrease in dose as the pH increases (3–8 ppm at pH of 7.5). Ortho-phosphate works by accelerating film formation on steel either through air-formed metal oxide or by precipitation as iron phosphate. The current dose rate (12–14 ppm in recirculating water) is based largely on the system target pH (6.9–7.2). As previously discussed, the lower the pH, the higher the PO₄ required. Another distinction of this chemistry is that it acts as a significant nucleation site for calcium in the scale prevention process. At manageable levels, the nucleated crystalline structure can be dispersed using polymers. However, programs must be careful when using ortho-phosphate. When the difference between filtered and unfiltered PO₄ is greater than 2 ppm, it can be assumed that there is not enough polymer to disperse the large amount of Ca₃PO₄ (tricalcium phosphate) and a severe scaling condition will occur. In this case, programs typically must either blowdown excessively or supplement with additional polymer feed until the condition improves.

4.2 PNNL Recommendation

The PNNL assessment team recommended that INL evaluate the scale and corrosion chemistry program currently in use to protect the ATR SCS and the UCW System. The assessment team also recommended that INL consider a move away from the ortho-phosphate-based control. The assessment team recognized that any wholesale move away from the current chemistry program should incorporate a full systems-level analysis, including the complete characterization of current equipment conditions, metallurgy evaluations, measurement of current and proposed corrosion rates, non-destructive pitting or thickness evaluation, and heat exchanger cleanliness.

Accordingly, the assessment team recommended that INL evaluate a treatment program to enable the system to run higher cycles while maintaining appropriate corrosion control. This likely would be a combination of cathodic corrosion control and scale inhibition using an organic phosphate such as phosphonobutane-tricarboxylic acid (PBTC), or hydroxyethylidene diphosphonic acid (HEDP). If proper chemistry were incorporated into the ATR facility, coupled with appropriate blowdown control, the PNNL assessment team calculated that approximately 17 M gpy could be saved. This would yield an estimated energy savings of \$2,100 per year.

4.3 INL Evaluation

4.3.1 SCS and UCW Analysis

As noted by PNNL, the first step to take before initiating any changes in the ATR chemistry program is to complete a full systems-level analysis. The PNNL assessment team listed the following facets to be considered:

- Characterization of current equipment conditions
- Metallurgy evaluations
- Current and proposed corrosion rates
- Non-destructive pitting evaluation
- Heat exchanger cleanliness.

Discussions with INL personnel added other aspects of the systems and implementation that would require investigation and would impact costs:

- Destructive analysis of metallurgical samples
- Air permitting applicability determination
- Industrial Wastewater Reuse Permit investigation
- Proposed impacts to aquifer through cold waste discharge
- Impacts on biological treatment of changes in corrosion control
- Current and proposed water usage
- Current and proposed precipitate formation
- Safety and industrial hygiene review of proposed chemicals
- Implementation schedule impacts
- Current and proposed chemical and operating costs
- Funding availability and priorities
- Storage space and co-storage-compatibility issues
- Procedure preparation
- Operator training.

The various drivers for the analysis of these different areas to be considered for a change in chemistry include; equipment age and reliability, personnel and public safety and health, state and national environmental regulations, stake holder (state, tribal, local) concerns, and environmental stewardship. The possibility of causing a primary to secondary leak in the 50-year-old primary heat exchangers alone demonstrates the necessity of completing a thorough analysis.

4.3.2 Water Usage

PNNL's estimated potential water usage reduction of 17 M gallons annually appears to be overly optimistic. INL personnel reviewed current and proposed water usages assuming a varying number of cycles of concentration (COC). The present ATR operating limit for COC is 5.5. Table 1 provides a comparison of water savings versus operating at the present COC limit. The assumptions for the calculations to generate the table are:

- Evaporation rate: 750 gpm
- Annual operating days: 280
- Makeup water cost: \$0.0007 per gallon.

Table 1. ATR SCS water usage with varying cycles of concentration.

COC	Blowdown Rate (gpm)	Makeup Rate (gpm)	Annual Makeup (gpy)	Annual Blowdown (gpy)	Water Savings ^a (gpy)	Water Savings ^a (%)	Savings ^a (\$/y)
4.2	179	929	374,400,000	72,000,000	-17,018,182	-4.8%	-11,364
4.3	174	924	372,725,581	70,325,581	-15,343,763	-4.3%	-10,292
4.4	170	920	371,127,273	68,727,273	-13,745,455	-3.8%	-9,259
4.5	167	917	369,600,000	67,200,000	-12,218,182	-3.4%	-8,264
4.6	163	913	368,139,130	65,739,130	-10,757,312	-3.0%	-7,305
4.7	160	910	366,740,426	64,340,426	-9,358,608	-2.6%	-6,380
4.8	156	906	365,400,000	63,000,000	-8,018,182	-2.2%	-5,486
4.9	153	903	364,114,286	61,714,286	-6,732,468	-1.9%	-4,622
5	150	900	362,880,000	60,480,000	-5,498,182	-1.5%	-3,788
5.1	147	897	361,694,118	59,294,118	-4,312,300	-1.2%	-2,981
5.2	144	894	360,553,846	58,153,846	-3,172,028	-0.9%	-2,199
5.3	142	892	359,456,604	57,056,604	-2,074,786	-0.6%	-1,443
5.4	139	889	358,400,000	56,000,000	-1,018,182	-0.3%	-710
5.5	136	886	357,381,818	54,981,818	0	0.0%	0
5.6	134	884	356,400,000	54,000,000	981,818	0.3%	689
5.7	132	882	355,452,632	53,052,632	1,929,186	0.5%	1,357
5.8	129	879	354,537,931	52,137,931	2,843,887	0.8%	2,005
5.9	127	877	353,654,237	51,254,237	3,727,581	1.0%	2,635
6	125	875	352,800,000	50,400,000	4,581,818	1.3%	3,247
6.1	123	873	351,973,770	49,573,770	5,408,048	1.5%	3,841
6.2	121	871	351,174,194	48,774,194	6,207,624	1.7%	4,419
6.3	119	869	350,400,000	48,000,000	6,981,818	2.0%	4,981
6.4	117	867	349,650,000	47,250,000	7,731,818	2.2%	5,528
6.5	115	865	348,923,077	46,523,077	8,458,741	2.4%	6,061
6.6	114	864	348,218,182	45,818,182	9,163,636	2.6%	6,579
6.7	112	862	347,534,328	45,134,328	9,847,490	2.8%	7,084
6.8	110	860	346,870,588	44,470,588	10,511,230	2.9%	7,576
6.9	109	859	346,226,087	43,826,087	11,155,731	3.1%	8,055
7	107	857	345,600,000	43,200,000	11,781,818	3.3%	8,523
7.1	106	856	344,991,549	42,591,549	12,390,269	3.5%	8,979
7.2	104	854	344,400,000	42,000,000	12,981,818	3.6%	9,424
7.3	103	853	343,824,658	41,424,658	13,557,160	3.8%	9,858
7.4	101	851	343,264,865	40,864,865	14,116,953	4.0%	10,281
7.5	100	850	342,720,000	40,320,000	14,661,818	4.1%	10,695

a. Note that negative values for savings are unrealized makeup water cost savings under the present chemistry regimen.

Typical COC values at the ATR range around 5 during prolonged periods of operation. Table 1 shows that by increasing the typical COC to 5.5, makeup water could be reduced approximately 5.5 M gallons annually. Savings resulting from eliminating that makeup water would be \$3,788.

Maintaining COC values at 6 through a change in chemistry would save an additional 4.5 M gallons of makeup water and \$3,247 annually. These amounts are considerably less than the 17 M gallons estimated by PNNL.

4.3.3 Scale Issues

The biggest concern for increasing COCs in the ATR SCS is the increased probability of scaling in the system. If scale from magnesium and calcium are controlled, the next chemical of concern is silica (as SiO_2). The Nalco Water Handbook describes silica scale as extremely tenacious, highly insulating, and very difficult to remove (Nalco Company 2009). Hydrofluoric acid is used for silica-scale removal. The PNNL water usage assessment team alluded to 150 ppm as a routinely used limit for silica in recirculating water. Cal Water has prepared a graph of silica solubility versus temperature that has silica solubility at approximately 120 mg/l at 86°F (30°C) (Peairs 2003). A similar graph by Dow Chemical Company shows a slightly higher value at 138 mg/l at 86°F (Dow Chemical 2013). ATR makeup water contains silica, which was recently measured at a concentration of 29 mg/l.^a With this concentration, 5 COCs would be under the saturation limit of 150 mg/l, but 6 COCs would be well beyond it. If lower silica limits were considered, COCs could be limited to as low as 4.

4.3.4 Impact to Present ATR Biological Treatment Method

Changing the corrosion control regimen could negatively impact the efficacy of the biological treatment program. PNNL's recommended changes in chemistry would force a substantial increase in pH. The chemicals currently added to the SCS to eliminate biological growth are WRICO BGA, an algaecide, and sodium hypochlorite. Ashland Water Technologies, the supplier for the WRICO BGA, reported that raising pH would have little impact on WRICO BGA's performance.^b However, the efficacy of sodium hypochlorite changes substantially with pH higher than 7.5. Sodium hypochlorite added to pH neutral water forms hypochlorous acid, the active toxicant for biological growth. Sodium hypochlorite works well in systems with near neutral pH. However, raising the pH drives the ionization of the hypochlorous acid to form hypochlorite ions, which are considerably less effective as biological agents.^c Figure 2 shows the effects of changing pH on the percentage of hypochlorous acid in the system. Adopting a corrosion control system that requires pH above the present range would force a change in the biological treatment program, adding substantially to the cost of the change in corrosion control.

a. Ashland Water Technologies, Raw Water Analysis, Sample date: September 12, 2012.

b. Robert Hyatt, Ashland Water Technologies, telecom with Greg Hulet, May 9, 2013.

c. Ashland Water Technologies, Technical bulletin available only through field representative, "Chlorination – A Two-Edged Sword," provided 2013.

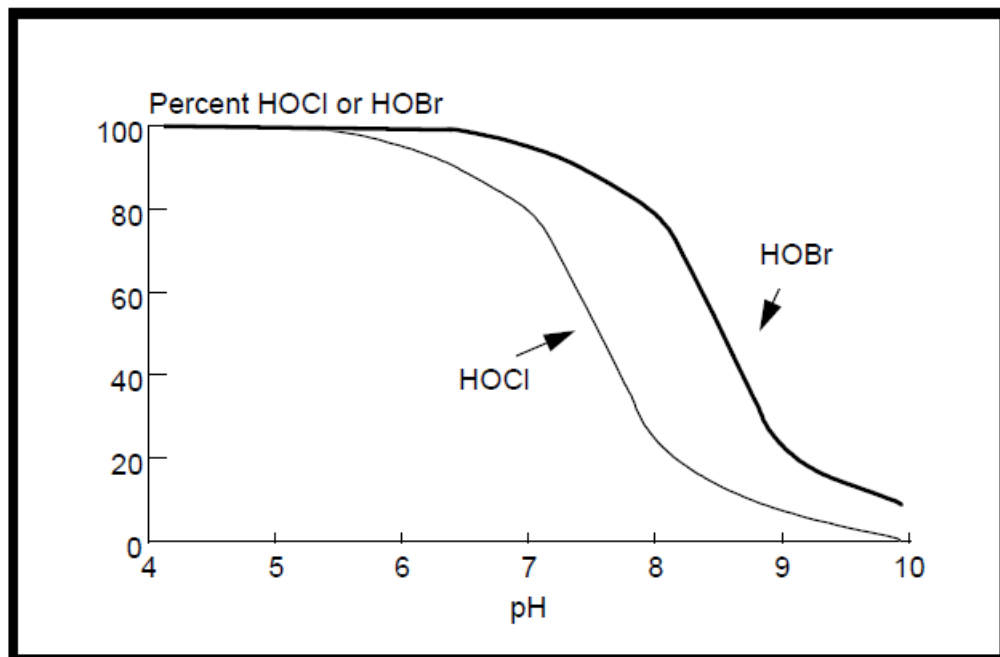


Figure 2. Hypochlorous acid (undissociated) in aqueous solutions.^c

4.3.5 Benefits and Concerns

The greatest concern of increasing COCs is the additional risk of forming scale in the SCS, especially on the primary heat exchanger tubes. High power runs will be much more frequent over the next several years. Loss of heat rejection capability would jeopardize the reactor plant's ability to perform those runs.

A second concern, previously described, is the possibility of having to adopt a new method of biological control if the corrosion control process requires a higher pH band than the current process. Costs of implementing the chemistry package would increase substantially if a change in biological treatment is required.

A marginal benefit is that increasing the COCs would reduce the amount of water pumped from the aquifer for makeup. However, the COCs increase would have essentially no impact on the overall amount of water lost from the aquifer. With the ATR operating at a given average power level, the amount of heat to be rejected would be a constant. That would lead to a constant amount of water lost to evaporation and wind drift in the cooling tower. Blowdown from the SCS goes to the CWP where a majority of the water percolates back to the aquifer. Lowering the amount of blowdown would diminish the amount that recharges the aquifer. Therefore, the net change to the water volume in the aquifer would be small, which essentially means that there is no substantial savings of water. A change in operating methods or chemistry would only be a benefit if costs were reduced.

Samples from monitoring wells down gradient from the CWP are tested to meet requirements of the state of Idaho. Increasing the COCs would decrease the amount of blowdown because a higher fraction of the initial water pumped would be available for heat rejection. However, the smaller recharge volume with a higher concentration of monitored chemicals could increase the concentration of those chemicals in the aquifer. The impact on the wastewater permit would need to be evaluated.

4.4 Implementation Cost

4.4.1 PNNL Cost Estimate

PNNL estimated an implementation cost of \$5,700.

4.4.2 INL Cost Estimate

An INL cost estimate was prepared to perform the design and construction for the proposed work. This preliminary cost estimate provided a range of:

A low end value of \$180,000

A targeted point value of \$243,000

A high end value of \$365,000

See Attachment 2, “ATR Water Study – INL Cost Estimate: Replace Inorganic PO₄ Scale/Corrosion Control Chemistry,” for a summary level report of the target point value. A detailed cost estimate will be required to obtain funding if it is decided to implement this proposed measure.

4.5 INL Recommendation

ATR Engineering recommendation is to retain ortho-phosphate as its method of corrosion control for the SCS. Additionally, ATR makeup water should be analyzed for silica at to-be-determined intervals for several months to establish a baseline concentration of constituents that could impact scaling. Depending on the silica concentration determined, INL should investigate methods of maximizing COCs within established limits, while using the present chemistry controls. Through this adjustment in operating the system, water usage could be reduced. No changes would be implemented if state-monitored chemical discharge limits would be exceeded.

Staying with the current corrosion-control methods would prevent substantial expenditures from limited budgets that would result in little economic gain. Present budgets do not include funding to study or implement changes to SCS and UCW chemistry. Consideration will be made to perform the study if future funding becomes available.

5. AUXILIARY COOLING WATER SUPPLY FOR ATR HVAC DURING OUTAGES

PNNL Recommendation 3

5.1 Description

Raw water, which is untreated well water, is supplied to the reactor building TRA-670 via a 6-in. line originating from the TRA-619 raw water pump house. In addition to the HVAC systems mentioned in the PNNL report, TRA-670 uses this raw water to cool auxiliary equipment such as the heat exchangers for the Primary Coolant System (PCS), pressurizing pump lube oil coolers, and cooling the loop primary cubicle chiller unit, which is a simple finned heat exchanger (radiator) and ventilation fan. As mentioned in the PNNL report, this raw water also provides cooling for numerous air conditioning units including those for the reactor, loop, and process control rooms, along with other critical computer rooms, all of which contain temperature sensitive electronic and computer equipment. The 6-in. raw water header that enters the building reduces to a 4-in. distribution header, which is reduced further to supply cooling water to the auxiliary equipment mentioned above. All of the heat exchangers are single pass units (i.e., the raw water used for cooling passes through each heat exchanger once). The auxiliary cooling water discharge is collected in a 6-in. cold waste drain line and routed from building TRA-670 to the TRA-671, the secondary coolant pump house, where it is diverted either to the cooling tower basin or to the CWP via appropriate valve lineups.

During the ATR operations this auxiliary cooling water discharge is directed to TRA-771, the ATR Cooling Tower basin, and used as makeup water (fresh water added to the SCS to replace water lost through evaporation and/or blowdown). When the ATR is shutdown and the cooling tower is not operating, the auxiliary cooling water discharge is directed to the cold waste system and eventually to the CWP.

Heat from the ATR is transferred to the SCS via the PCS heat exchangers. The SCS water is pumped from the cold well beneath TRA-671, the secondary pump house, which is fed from the cooling tower basin through the shell side of the PCS heat exchangers. From the PCS heat exchangers the SCS water is directed over the ATR cooling tower to dissipate its heat through evaporation and then collects in the cooling tower basin. The SCS water then flows through debris screens as it enters the cold well. The SCS is also chemically treated for corrosion control.

5.2 PNNL Recommendation

The recommendation by PNNL is to install a new system that will pump SCS water from the cooling tower basin during ATR outages into the 6-in. raw water supply line just before it enters TRA-670. Normal raw water supplied to HVAC units for cooling would be isolated and the SCS water used instead. This SCS water from the ATR cooling tower basin would pass through all the heat exchangers currently supplied by raw water and would be circulated back to the cooling tower basin. Figure 3, ATR Auxiliary Cooling Diagram, depicts the current condition in black and the PNNL proposal in red. PNNL projected a water savings of 49 M gallons with an associated energy savings of \$6,000 per year.

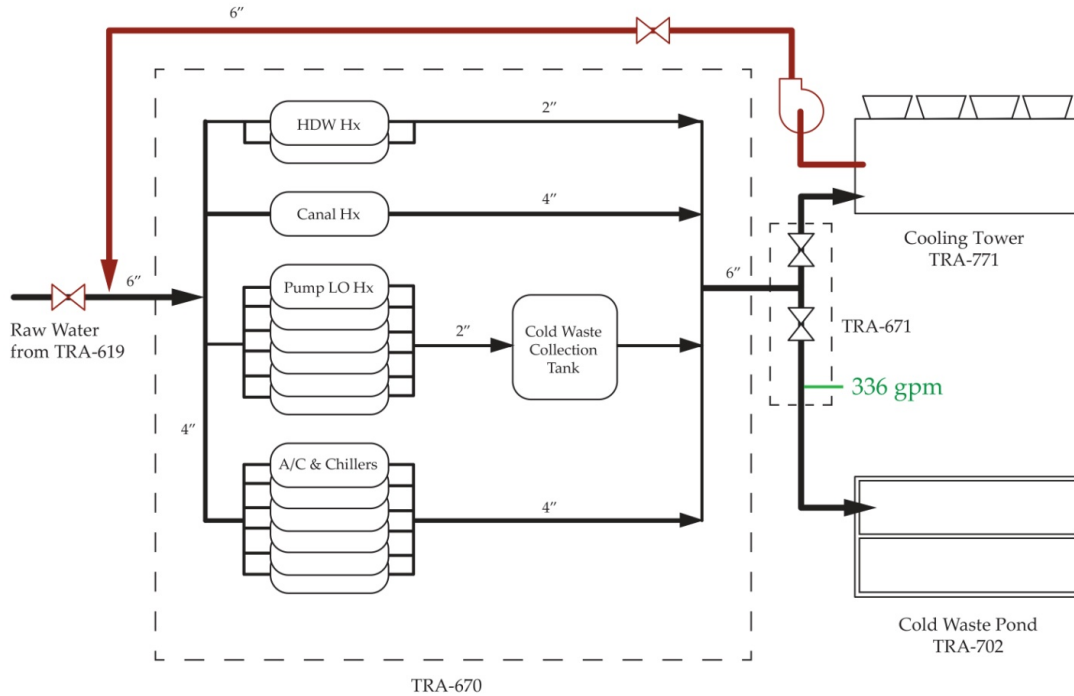


Figure 3. ATR auxiliary cooling diagram showing the current routing in black and the proposed routing in red.

5.3 INL Evaluation

SCS water is used in many larger heat exchangers (i.e., PCS, high-pressure demineralized water, diesel lube oil, and diesel jacket water), but it is always used on the shell side of the heat exchanger. SCS water has high levels of minerals, chemicals, debris, sediment, etc., and previous attempts to use SCS water on the tube side of smaller heat exchangers have been unsuccessful. The decommissioned ATR Waste Heat Recovery System (WHRS) is the best example where it took less than 1 year for flow to be restricted in nearly all of the air to water heat exchangers. Problems with the automatic vent valves seating were also encountered, which resulted in the flooding of a number of buildings. The concept behind the WHRS was to use heat from the ATR in a tertiary loop that circulated hot SCS water returning to the cooling tower via the PCS heat exchangers to heat various buildings throughout the ATR Complex. Strainers installed to trap solids known to be suspended in the SCS water failed to prevent heat exchanger fouling, which eventually damaged the system. The WHRS was permanently shutdown in the early 1990s due the increased maintenance costs and operational burdens associated with system.

The PNNL report proposes a route for the auxiliary loop that would start at the TRA-670 cooling tower basin and connect to the 6-in. raw water supply line that enters TRA-670 through the east wall of the first basement. The recommendation would require installation of a pump, pump controls, valves, and underground piping. Figure 4 shows there are significant underground utilities along the proposed route that would complicate the installation of the auxiliary loop piping and isolation valves. A suitable location for the pump and controls would also be required.

Implementing the PNNL recommendation could potentially create a cross connection with the backup ATR Complex potable water system. A cross connection with potable water would require the installation to meet American Water Works Association (AWWA), American National Standards Institute (ANSI)/National Science Foundation (NSF) standards and Idaho Administrative Procedures Act (IDAPA) 58.01.08, "Idaho Rules for Public Drinking Water Systems. A detailed review of these requirements will be performed if this option is considered.

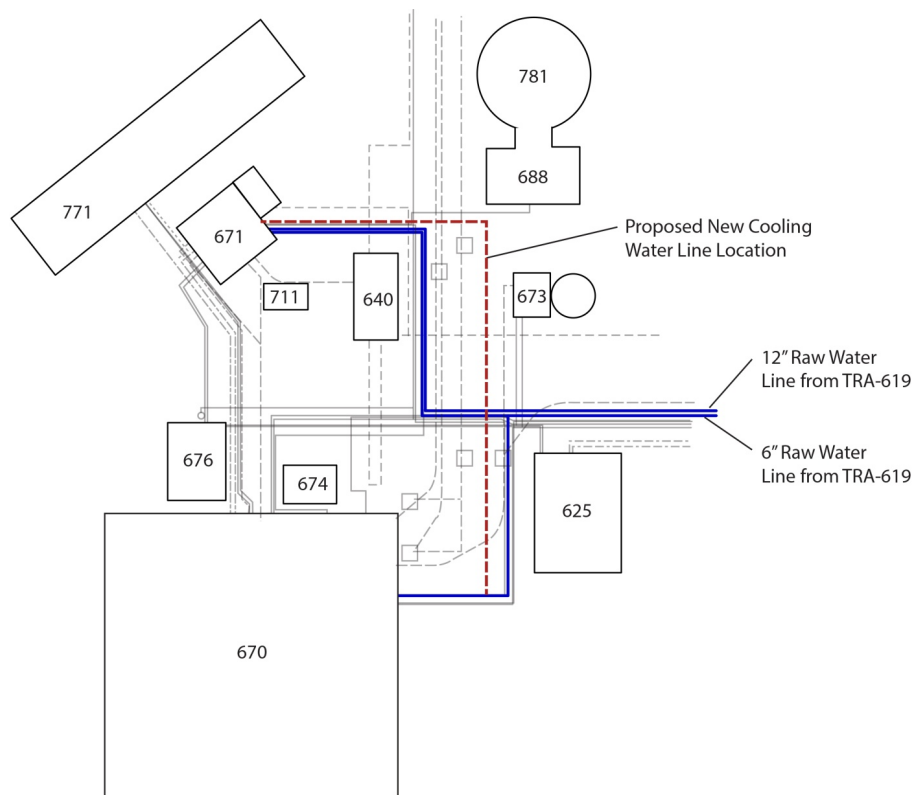


Figure 4. Underground utilities schematic.

5.4 Implementation Cost

5.4.1 PNNL Cost Estimate

The PNNL study estimated a total installed cost of \$35,600 with an annual total energy savings of \$6,000 per year. A more comprehensive installation cost estimate would likely be significantly higher, which is due mainly to the engineering design, configuration control work, operator training, and excavation costs. Additional maintenance costs associated the fouling of the heat exchangers caused by the SCS water (addressed in more detail below) and the new equipment (i.e., pumps, valves, backflow prevention assemblies, pressure and flow gauges) would offset any cost savings achieved by reduced water usage.

5.4.2 INL Cost Estimate

An INL cost estimate was prepared to perform the design and construction for the proposed work. This preliminary cost estimate provided a range of:

- A low end value of \$1,530,000

- A targeted point value of \$1,910,000

- A high end value of \$2,480,000

See Attachment 3, “ATR Water Study – INL Cost Estimate: Auxiliary Cooling Water Supply for ATR HVAC during Outages,” for a summary-level report of the target point value. A detailed cost estimate will be required to obtain funding if it is decided to implement this proposed measure.

5.5 INL Recommendation

It is the INL's recommendation not to implement the PNNL recommendation to install a new system that will pump SCS water from the cooling tower basin during ATR outages into the 6-in. raw water supply line just before it enters TRA-670. The inadequacy of SCS water as a cooling medium in the tube side of smaller heat exchangers, the high-installation costs, the additional maintenance costs, and operational burdens associated with a system of this type would provide little or no benefit to the program.

6. DRY-FLUID COOLING TO REPLACE ONCE-THROUGH AIR COMPRESSOR COOLING WATER

PNNL Recommendation 4

6.1 Description

Compressed air is used to support programs and equipment such as the various craft shops, machine shops, laboratories, fire protection systems, the demineralized water plant, the raw water pump house, and the ATR. There are three large air compressors located inside building TRA-609 that provide the ATR Complex with compressed air (see Figure 5). The compressed air is filtered and dried downstream of the compressors and then stored in air receiver tanks located on the south side of the building. Valves and piping inside TRA-609 separate the compressed air into Plant Air (PA) and Instrument Air (IA). The PA and IA lines are then distributed underground to the various buildings depending on the need.

The ATR and its associated utility support systems are the primary users of compressed air at the complex, so it is critical to keep these compressors operating. The ATR Complex uses 350–400 cfm on average, which requires one of the three air compressors to operate 24 hours a day, 365 days a year. The other two compressors are in standby mode and will automatically start if additional air is needed and/or in the event that the lead compressor fails.

The cooling water for the TRA-609 air compressors is raw water with fire water as a backup. The cooling water discharge is presently piped to the cold waste system. Refer to Figure 6, “TRA-609 Air Compressor Cooling Water Diagram.”



Figure 5. TRA-609 air compressor.

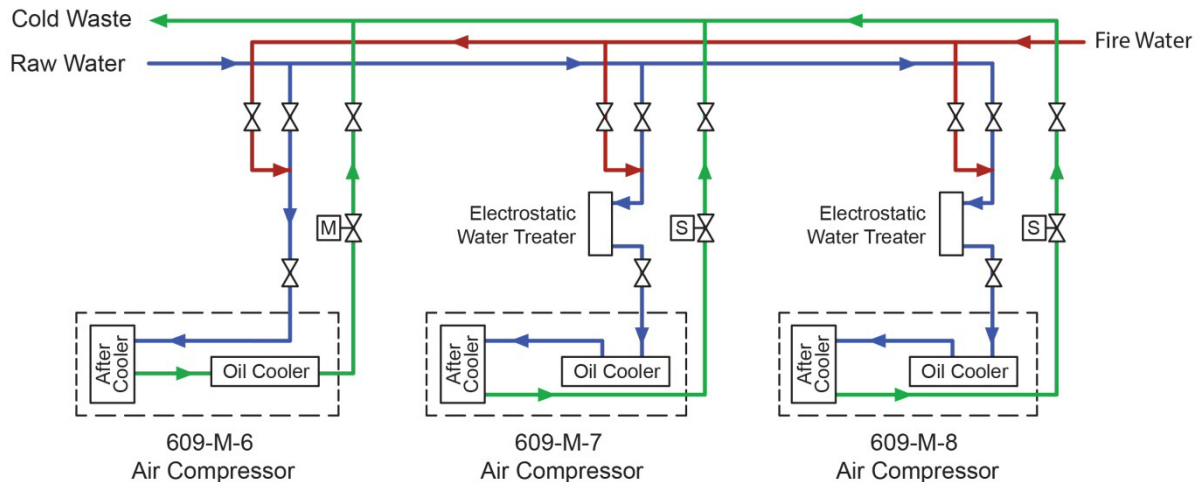


Figure 6. ATR air compressor cooling water diagram.

6.2 PNNL Recommendation

PNNL noted that the annual flow of cooling water through the air compressor heat exchangers was approximately 45 M gallons of non-potable water, based on a 24 hour/7 day per week flow regardless of cooling demand. PNNL recommended installing a skid-mounted closed loop dry-fluid cooling system to replace the once-through cooling water system that is presently being used.

6.3 INL Evaluation

Providing redundancy in the compressed air system is very important and must be considered as part of this proposed modification. A constant reliable supply of clean compressed air to TRA-670 and supporting facilities is critical to the operation of the ATR. Therefore, redundancy was designed into the system. For example, all three compressors can run on commercial electrical power with one of the compressors connected to the backup diesel generator. Also, there are redundant inlet filters, air dryers, outlet filters, and air receiver tanks, along with independent distribution lines, to ensure uninterrupted compressed air service to ATR Complex. As mentioned above, the primary cooling water also has a backup in the form of fire water. There is also a portable, diesel powered air compressor located outside to the south of the building as a standby to the two standby compressors. To ensure redundancy in the compressed air system, two separate standalone dry-fluid cooling units should be installed if this project were to be implemented. The duplication of equipment is required to maintain system reliability while providing flexibility during maintenance periods.

The dry-air cooling systems would probably need to be installed outside due to the limited floor space inside building TRA-609. This would significantly increase the installation costs, operational costs, maintenance costs, increase reliability risk, and add new personnel safety hazards during inclement weather.

The cooling water discharge from the TRA-609 air compressors is routed to the cold waste system and eventually ends up in the TRA-702 CWP. The project evaluated the potential to route air compressor cooling water discharge to the sewage pond in addition to the CWP. Any water conservation project that reduces effluent to the CWP must be evaluated to determine the impact the CWP prior to project implementation.

6.4 Implementation Cost

6.4.1 PNNL Cost Estimate

The PNNL study did not include the full scope of work necessary to install, maintain, and operate a dry-fluid cooling system for the ATR Complex Compressed Air system. Any new system would require design engineering, configuration control work, compressor heat exchanger modifications, piping modifications, electrical modifications, procedure revisions, and training for all the operators and other affected personnel. It is assumed that PNNL did not consider the redundancy requirement, therefore estimated installation of only one dry-fluid system. The PNNL study identified the estimated total installed cost to be \$67,300 with an annual energy cost savings of \$5,400 per year. A more comprehensive installation cost estimate would likely be significantly higher. The additional maintenance cost associated with the new equipment (dry fluid cooling systems, heat exchangers, electrical switchgear, pressure and flow gauges, cooling fans, pumps, etc.) would significantly increase the payback period.

6.4.2 INL Cost Estimate

An INL cost estimate was prepared to perform the design and construction for the proposed work. This preliminary cost estimate provided a range of:

- A low end value of \$1,800,000
- A targeted point value of \$2,229,000
- A high end value of \$2,900,000

See Attachment 4, “ATR Water Study – INL Cost Estimate: Dry-Fluid Cooling to Replace Once-Through Air Compressor,” for a summary level report of the target point value. A detailed cost estimate will be required to obtain funding if it is decided to implement this proposed measure. The INL cost estimate is based on the flow diagram in Figure 7, which includes redundant dry-fluid cooling systems.

6.5 INL Recommendation

It is the INL's recommendation not to implement the proposed measure to install a dry-fluid cooling system for the ATR Complex air compressors. The high initial installation costs, the additional maintenance costs, the added reliability risk with a system of this type, (i.e., higher probability failure rate due to the additional pumps, control valves, fans, etc., versus the very simple cooling system that is presently being used), the additional operational burdens and the problems that installing the new cooling system outside creates would provide little or no benefit to the program.

7. ATR SEWAGE LAGOON OPTIONS

INL Recommendation 1

7.1 Description

The evaporative sewage lagoon, installed in 1995, consists of two cells, both lined with bentonite clay. After construction, both cells were seepage tested, and Cell 2 failed the test. As a result, Cell 2 was reconstructed by removing the clay liner, installing a PVC geomembrane liner, and then reinstalling the clay material on top for protection of the PVC liner.

The evaporative sewage lagoon (see Figure 8) located east of the facility was originally designed to accommodate a significantly higher discharge rate than the ATR Complex population to allow for growth. Because the lagoon is underutilized, the surface evaporation rate exceeds the waste water inflow. This poses a risk of the lagoon clay liner drying out, cracking, and leaking. Supplemental water, averaging 14 M gpy, is added to the lagoon, mostly during the summer months when evaporation is high, to keep the cells at a prescriptive level. Raw water is fed directly from building TRA-608 to a nearby sanitary sewer manhole. Figure 9 shows raw water discharging from a fire hose into the manhole.

In 2010, BEA conducted a seepage test of the sewage lagoon. Both cells passed the test with seepage rates below the Idaho Department of Environmental Quality (IDEQ) threshold operating criteria of 0.25 in. per day. The observed seepage rate for Cell 1 was the highest, greater than 0.125 in. per day, while the rate for Cell 2 was well below 0.125 in. per day.

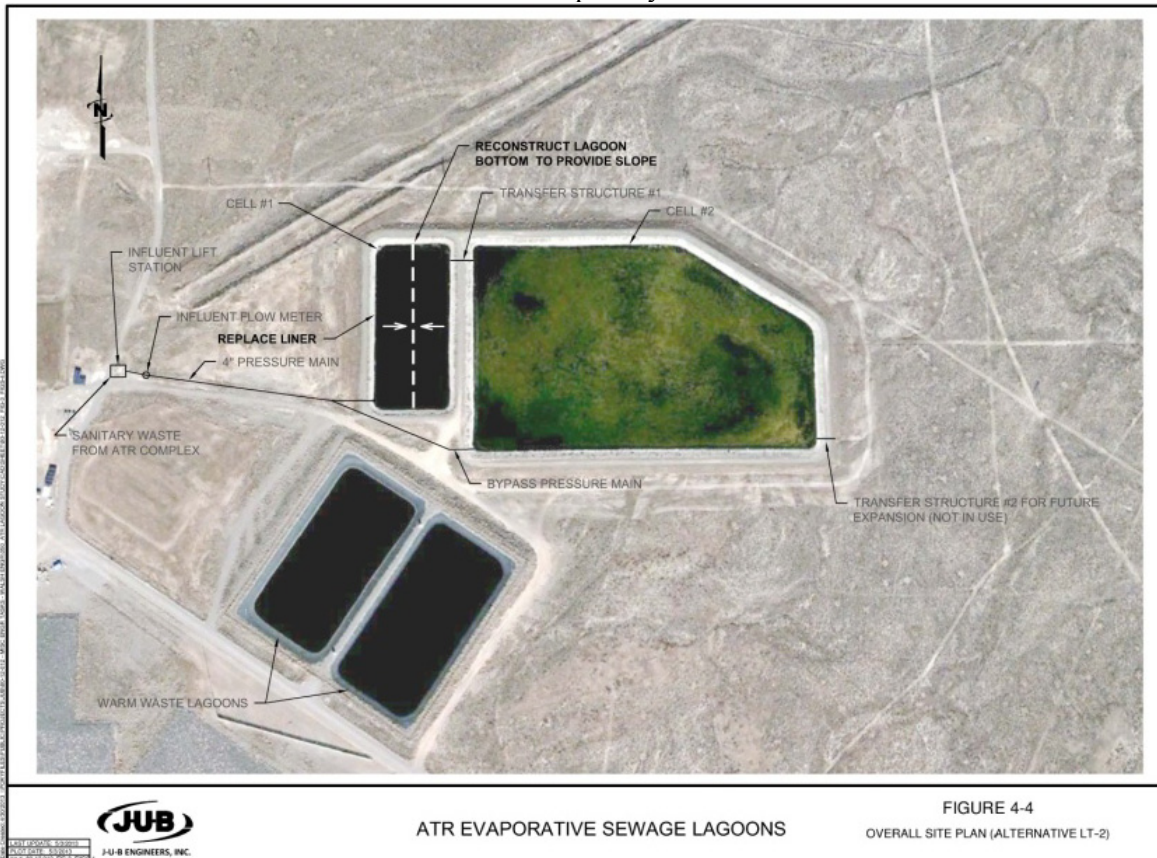


Figure 8. ATR Complex evaporative sewage lagoon.



Figure 9. Supplemental raw water added to the sewage drain.

7.2 INL Evaluation

INL recently contracted with an independent engineering firm, J-U-B Engineers Inc. to perform a study that calculated the flows and water balance for the sewage lagoon to determine the quantity of supplemental water needed to maintain liner integrity. The following is a summary of the J-U-B report, INL/EXT-13-29642, Advanced Test Reactor Complex Sewage Lagoon Evaluation (INL 2013a).

The average annual precipitation is used in analyzing the capacity of an evaporative lagoon. The 10-year high (wet) average is 11.6 in. and the 10-year low (dry) average is 5.25 in. The determined annual evaporation rate from the ATR Complex sewage lagoon is 31.60 in. Therefore, the net annual evaporation from the lagoon during a wet year is estimated to 20 in.

The flow generated from the ATR Complex and delivered to the sewage lagoon was determined based on monthly readings taken from the influent-pump-station flow meter. The average annual total flow from the ATR Complex is 17,599,720 gpy consisting of 5,649,986 gallons from the sanitary waste and 11,949,733 gallons from supplemental water flow.

A water balance evaluation was performed based on the influent flow and calculated evaporation, precipitation, and seepage. Modeling scenarios were developed for wet and dry-year conditions. The model assumed that flow enters Cell 1 and then overflows into Cell 2 when the water level exceeds Cell 1 capacity. Based on the current annual precipitation, evaporation from the lagoon and influent to the lagoon, the J-U-B report indicates there is adequate water flow to maintain Cell 1 liner integrity. The J-U-B report clearly states Cell 2 does not require a minimal water level or cap because it has a PVC liner. Therefore, supplemental water does not need to be added to the sewage lagoon. Cell 2 can be dry without impacting the liner or its seepage characteristics. Eliminating the 12 M gpy supplemental water at a cost of \$0.0007 per gallon yields an annual energy savings of \$8,400.

Operational concerns were expressed regarding no fence around the perimeter of the lagoon. The IDEQ requirements for wastewater lagoons state:

“Fencing. The pond area shall be enclosed with an adequate fence to prevent entering of livestock and discourage trespassing. This requirement does not apply to pond areas which store or impound Class A municipal reclaimed effluent.” IDAPA 58.01.16.493.09.c.i

However, the IDAPA regulations also state the following:

“These rules pertain to all new and existing municipal wastewater lagoons, including discharging or non-discharging lagoons, municipal wastewater treatment lagoons, municipal wastewater storage lagoons, and any other municipal wastewater lagoons that, if leaking, have the potential to degrade waters of the state. Lagoons are also sometimes referred to as ponds. Section 493 does not apply to industrial lagoons or mining tailings ponds, single-family dwellings utilizing a single lagoon, two (2) cell infiltrative system, those animal waste lagoons excluded from review under Section 39-118, Idaho Code, or storm water ponds.” IDAPA 58.01.16.493.01.a.

“Lagoons utilized for equalization, percolation, evaporation, and sludge storage do not have to meet the requirements set forth in Subsections 493.05 through 493.10, but must comply with all other applicable sub sections.” IDAPA 58.01.16.493.01.b.

Because the lagoon is an evaporative lagoon, IDAPA 58.01.16.493.09.c.i or iii should not be applicable. Also, the existing riprap around the lagoon perimeter should minimize big game intrusion. However, if big game intrusion in the lagoons is regularly observed, the construction of a fence around the lagoon and installation of warning signs is recommended.

7.3 INL Implementation Cost Estimate

An INL cost estimate was prepared to perform the design and construction for the proposed fence in case big game is observed entering cells of the lagoon. This preliminary cost estimate provided a range of:

A low end value of \$460,000

A targeted point value of \$574,000

A high end value of \$740,000

See Attachment 6, “ATR Water Study – INL Cost Estimate: ATR Sewage Lagoon Options,” for a summary level report of the target point value. A detailed cost estimate will be required to obtain funding if it is decided to implement the installation of a fence.

7.4 INL Recommendations

Since the control of seepage relies on the integrity of its clay liner, a water cap must be maintained in Cell 1 to keep it from drying out and cracking. Based on the J-U-B report, normal influent and precipitation maintains the water level in Cell 1 to keep it from drying out and cracking. Cell 2 has a PVC liner, so it does not require a water cap. Therefore, the INL recommendation is to continue the use of the existing lagoons in their current configuration, but discontinue the addition of supplemental water. It is also recommended to continue monitoring and tracking the water level in Cell 1 and re-evaluate the need for supplemental water should the level in Cell 1 fall below the minimal needed to maintain the clay liner.

It was determined that the existing lagoon does not need to be fenced because it is not required by the State of Idaho and there is rock riprap around the lagoon perimeter.

8. TRA-609 AIR COMPRESSOR COOLING WATER DISCHARGE

INL Recommendation 2

8.1 Description

There are three large air compressors located inside building TRA-609 that provide the ATR Complex with compressed air. The compressed air is filtered and dried downstream of the compressors and then stored in air receiver tanks located on the south side of the building. Valves and piping inside TRA-609 separate the compressed air from the receiver tanks into PA and IA. The PA and IA lines are then distributed underground to the various buildings depending on need. PA is primarily used to run air powered equipment, hose reels, etc., while IA is used for instrumentation. Compressed air is used to support programs and equipment such as the various craft shops, machine shops, laboratories, fire protection systems, demineralized water plant, raw water pump house, and the ATR.

The ATR and associated utility systems supporting the ATR is the primary user of compressed air at the complex, so it is critical to keep these compressors operating. The ATR Complex uses 350–400 cfm of compressed air on average, which requires one of the three air compressors to operate 24 hours a day, 365 days a year. The other two compressors are in standby mode and will automatically start if additional air is needed and/or in the event that the lead compressor fails.

The cooling water for the TRA-609 air compressors is raw water with fire water as a backup. The cooling water discharge is presently piped to the cold waste system. Refer to Figure 10, “ATR Complex and CWP plan view.”

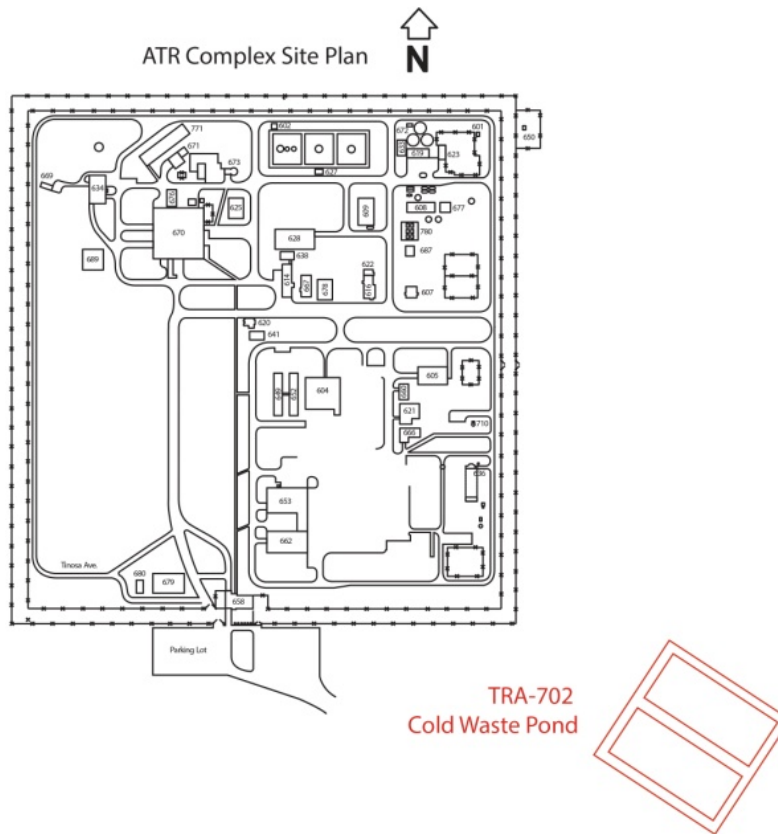
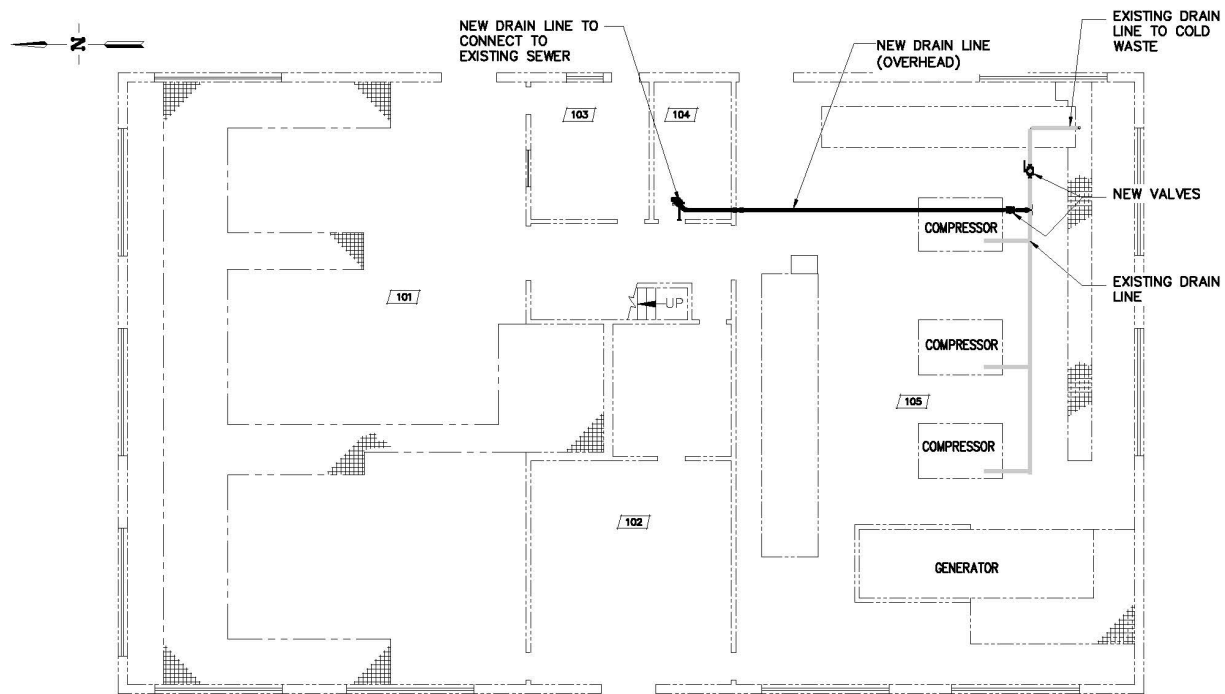


Figure 10. ATR Complex and CWP plan view.

8.2 INL Evaluation

The cooling water discharge from the TRA-609 air compressors presently discharges to the cold waste system. The proposed modification would install a tee, piping, and valves in the discharge header inside TRA-609 compressor building to allow the cooling water from the air compressors to be directed to either the sanitary sewer and/or the cold waste system. See Figure 11 for a proposed diverter valve installation. If additional water is needed during the summer months to keep the Cell 1 liner from drying out and leaking some or the entire air compressor once through cooling water could be diverted to Cell 1.



TRA-609 PLAN

Figure 11. Proposed diverter valve schematic.

The proposed work includes installing a tee, valves, and piping to provide two discharge paths for the TRA-609 air compressor cooling water discharge. This is a relatively simple modification. However, an evaluation must be performed to determine the impact of a decreasing the water being sent to the CWP. See Section 10, “ATR Cold Waste Pond Evaluation” for further evaluation concerning reducing “clean” wastewater discharge to the CWP. Assuming a savings of 14 M GPY at a cost of \$0.0007 per gallon the estimated energy savings is \$9,800 per year.

The advantages of implementing this project are a reduction in water usage, provisions for an alternate path for the cooling water discharge to allow maintenance on the cold waste line system downstream of building TRA-609 and an alternative method to provide supplemental water to the sewage lagoons if needed.

The disadvantage of this project is it decreases funding for other maintenance activities within the base infrastructure budget.

8.3 INL Implementation Cost Estimate

An INL cost estimate was prepared to perform the design and construction for the proposed work. This preliminary cost estimate provided a range of:

- A low end value of \$30,000
- A targeted point value of \$35,000
- A high end value of \$50,000

See Attachment 7, “ATR Water Study – INL Cost Estimate: TRA-609 Air Compressor Cooling Water Modification,” for a summary level report of the target point value. A detailed cost estimate will be required to obtain funding if it is decided to implement this proposed measure.

8.4 INL Recommendation

INL has determined that the annual practice of providing supplemental water to protect the sewage lagoon liner integrity is not required. However, other factors including blowing dust and animal intrusion may require best additional management practices to prevent seepage test failures in the future.

INL recommends long-term consideration of this measure as funding and project prioritization allow. Even though State of Idaho Industrial Waste Reuse Permit (IWRP) standards would not be exceeded, this modification should only be implemented if approved and reviewed by IDEQ since the ATR CWP Evaluation (see Section 10) determined that reducing “clean” wastewater will further degrade ground water quality.

9. TRA-628 HVAC CONTROL SYSTEM MODIFICATION

INL Recommendation 3

9.1 Description

The HVAC system in building TRA-628 is comprised of six self-contained water-cooled heat pumps. These heat pumps are located inside the building above the false ceiling. The cooling water for the heat pump compressors is raw industrial water fed from the building fire water riser and discharges to the CWP after a single pass through the heat pumps (see Figure 12). Presently, this cooling water flows continuously to provide cooling whether the compressor is operating or not. When a heat pump goes into the heating mode of operation, a solenoid valve opens to increase the cooling water flow even more.

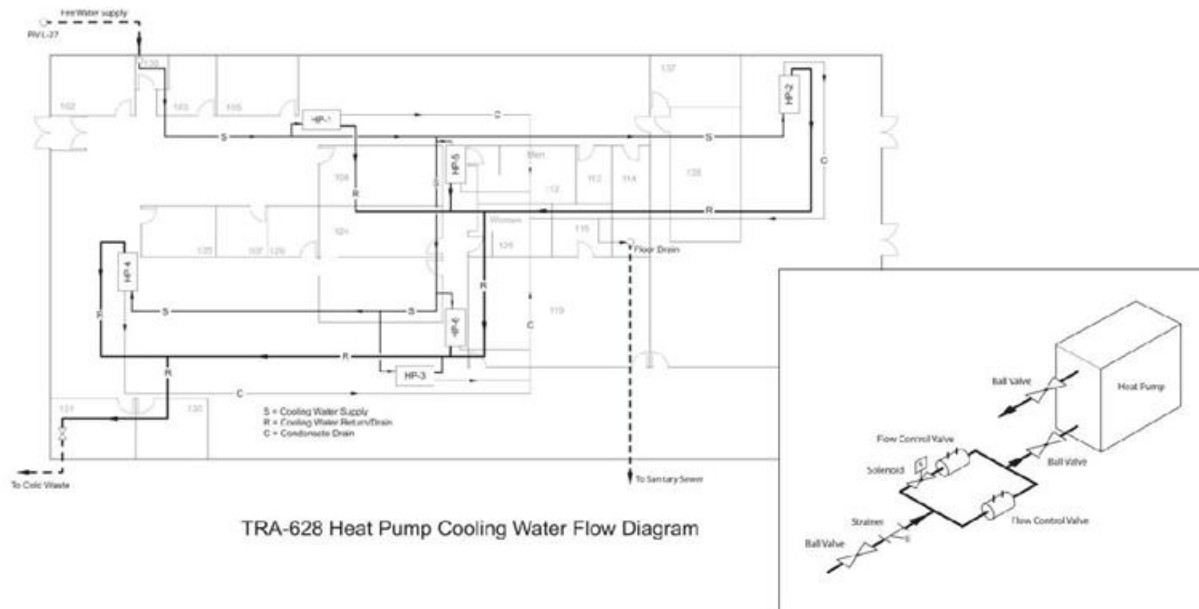


Figure 12. TRA-628 heat pump cooling water flow diagram.

9.2 INL Evaluation

Updating the HVAC control system and installing motor operated flow control valves would provide a system that would open a valve to allow cooling water flow when it is needed (i.e., when the heat pump compressor is actually running) and would close the valve when the compressor shuts off. The actual flow rates through the TRA-628 HVAC system are unknown as there is not a flow meter installed in the system. The Facility Manager believes there is a potential to reduce water consumption in excess of 5 M gallons a year if this strategy is implemented. With an energy cost of \$0.0007 per gallon, it is estimated that \$3,500 per year would be saved. The existing Johnson Controls system would need to be replaced with an Alerton control system containing motor operated flow control valves.

The cooling water discharge from the TRA-628 heat pumps is routed to the cold waste system and eventually ends up in the TRA-702 CWP. See Section 10, “ATR Cold Waste Pond Modification,” for further evaluation related to reducing “clean” wastewater discharge to CWP.

9.3 INL Implementation Cost Estimate

An INL cost estimate was prepared to perform the design and construction for the proposed work. This preliminary cost estimate provided a range of:

A low end value of \$250,000

A targeted point value of \$314,000

A high end value of \$400,000

See Attachment 7, “ATR Water Study – INL Cost Estimate: TRA-628 HVAC Control System Modification,” for a summary level report of the target point value. A detailed cost estimate will be required to obtain funding if it is decided to implement this proposed measure.

9.4 INL Recommendations

Upgrading the TRA-628 HVAC control system and installing motor operated flow control valves would be a benefit if funding could be secured and the reduction in flow rates to the CWP is acceptable. It is recommended that this strategy is implemented in two separate phases. Phase 1 would be to install a flow meter in the main cooling water header and take flow measurements for a year and trend the data to determine seasonal flow rates and possible water usage reductions that could be realized. Phase 2 would be to evaluate the data collected from Phase 1. If the analysis indicates that the potential water usage reduction is enough to warrant the modification, and the impact on the CWP is acceptable, then the upgrade to the HVAC controls system and installation of motor operated control valves should be completed.

The benefit of upgrading the control system is a reduction in water usage. Also, the new system would be much more reliable, repair parts would be more accessible, and the new system could be monitored and controlled remotely, similar to other INL systems.

10. ATR COLD WASTE POND EVALUATION

INL Recommendation 4

10.1 Description

Three of the proposals in this report would reduce approximately one-third to one-half of the total CWP effluent. The portion of the effluent stream recommended for diversion consists of raw, or “clean” cooling water, which combined with the other effluent generated from other sources, allows for compliance with the maximum effluent constituent concentrations outlined in the CWP Idaho IWRP. However, the reduction of “clean” water will concentrate chemicals discharged to the CWP and potentially have an adverse impact on groundwater. A detailed study, INL/EXT-13-29885, “Idaho National Laboratory Water Conservation Project Evaluation – Impact of Reducing Discharge to the Advanced Test Reactor Cold Waste Pond on Sulfate Concentrations in the Snake River Plain Aquifer,” provides an approximation of the potential impact to groundwater from reducing “clean” water discharges to CWP and concentrating chemicals in the effluent (INL 2013b). This section contains a summary of that study.

The CWP is located approximately 450 feet from the southeast corner of the ATR Complex compound (see Figure 13). The existing CWP was excavated in 1982. It consists of two cells, each with dimensions of 180 × 430 feet across the top of the berms, and a depth of 10 feet. Total surface area for the two cells at the top of the berms is approximately 3.55 acres. Maximum capacity is approximately 10,220,000 gallons (31.3 acre feet).

Wastewater discharged to the CWP consists primarily of non-contact cooling tower blowdown, once-through cooling water for air conditioning units, coolant water from air compressors, secondary system drains, and other non-radioactive drains throughout the ATR Complex. The wastewater flows through collection piping to the TRA-764 Cold Waste Sample Pit (see Figure 13) where the flow rate is recorded and Idaho IWRP compliance monitoring samples are collected. The wastewater then flows to the Cold Waste Sump Pit (TRA-703). The sump pit contains submersible pumps that route the water to the appropriate CWP cell through 8-in. valves.

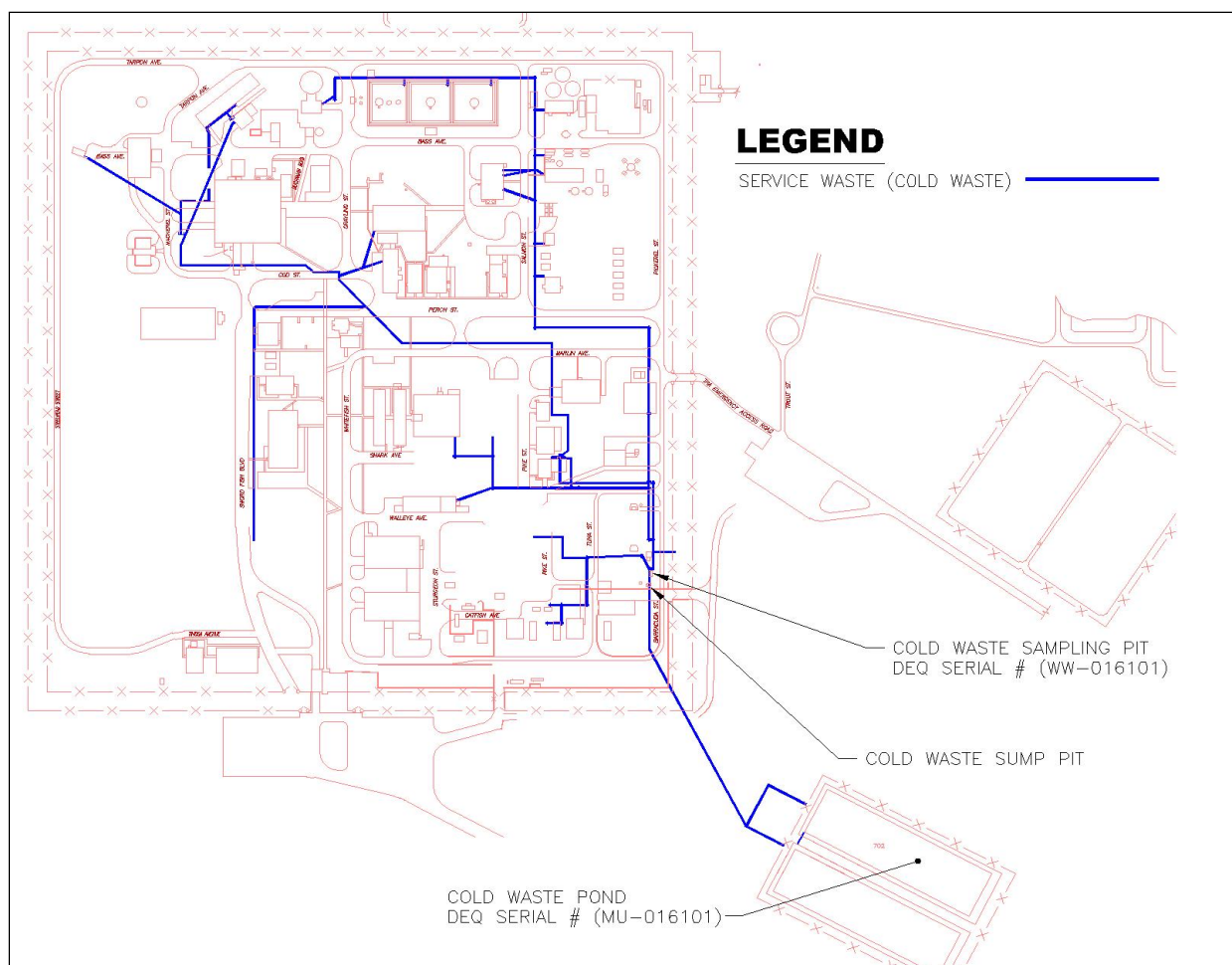


Figure 13. ATR Complex cold waste system flow schematic (Source: INL 2013c).

Wastewater enters the pond through concrete inlet basins located near the west end of each cell. Most of the water percolates into the porous ground within a short distance from the inlet basins. If the water level rises significantly in a cell (e.g., 5 ft) flow would be diverted to the adjacent cell, allowing the first cell to dry out. An overflow pipe connects the two cells at the 9-ft level. Normal operation is to route the wastewater to one cell at a time.

To determine potential impacts to groundwater from the CWP, groundwater samples are collected semiannually during April and October from five monitoring wells (USGS-065, TRA-07, USGS-076, TRA-08 and Middle-1823) in the Snake River Plain Aquifer downgradient of the CWP in accordance with the IWRP (Johnston 2008). Figure 14 shows the locations of the five wells and the inferred groundwater flow direction based on water level measurements conducted in April 2012 (INL 2013c). Note the groundwater flow direction is nearly perpendicular to the southwest side of the CWP. Also, well Middle-1823 is screened deeper (below the water table) which may explain why the water table is slightly higher than up-gradient well TRA-08.

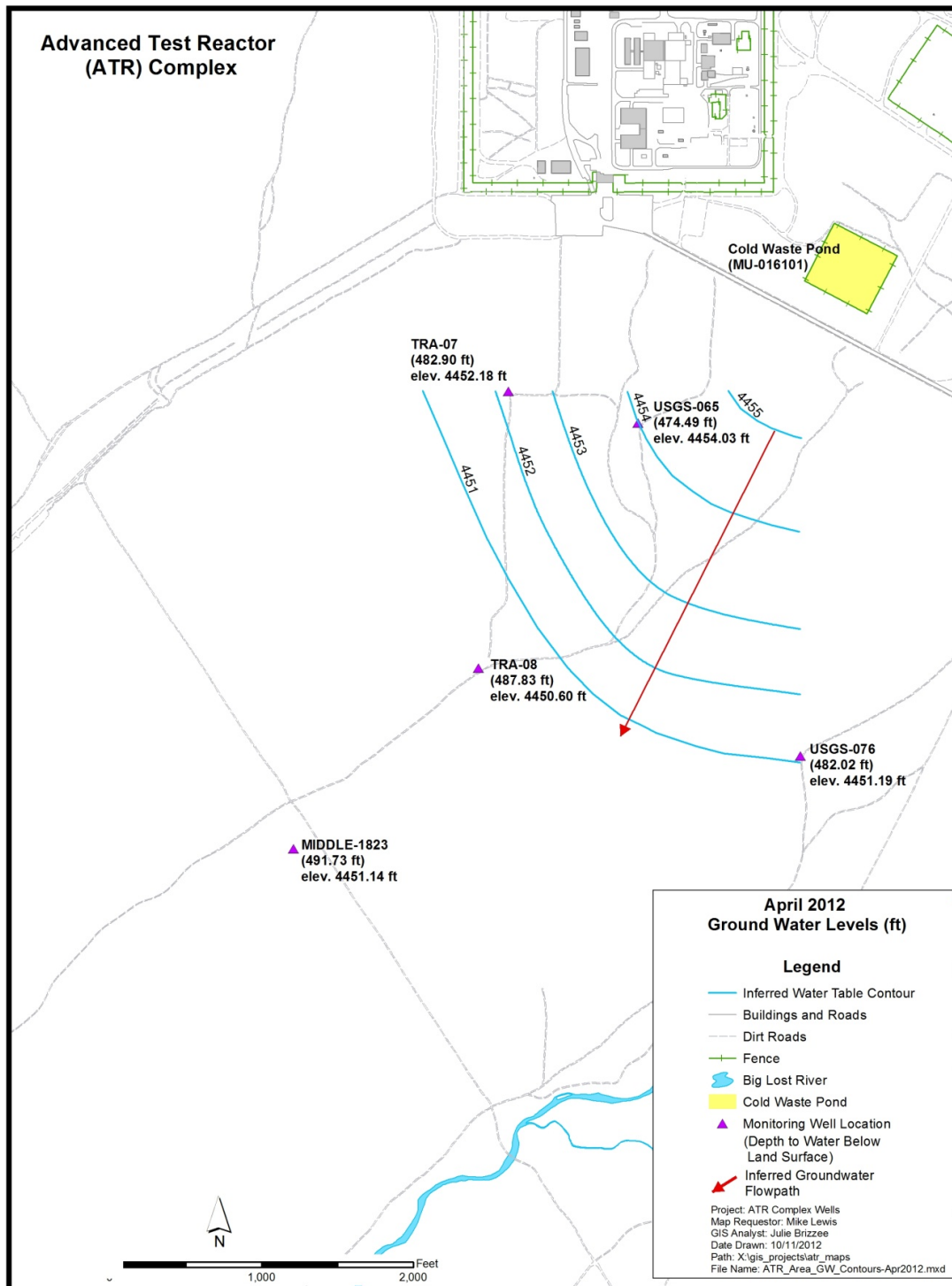


Figure 14. Locations of the ATR CWP Idaho IWRP monitoring wells, and the inferred groundwater flow direction based on April 2012 water level measurements (Source: INL 2013c).

The majority of water discharged to the CWP is raw or “clean” water pumped from the aquifer and used as cooling water for air conditioning units and air compressors. Raw water is also used to cool the ATR primary cooling system via heat exchangers and a cooling tower, but the evaporative cooling process for the cooling tower concentrates naturally occurring dissolved solids in the cooling tower blowdown (discharge) to the CWP. Raw water contains low levels of sulfate (~24 mg/L), but sulfate is also generated by reactions between sulfuric acid additives placed in the cooling tower water to control pH, and calcium and magnesium carbonates in the water. TDS and sulfate in the wastewater is of concern because of elevated levels in the aquifer downgradient of CWP.

The Idaho Ground Water Quality Rule (IDAPA 58.01.11) Secondary Constituent Standards for sulfate and TDS are 250 mg/L and 500 mg/L, respectively. Secondary Constituent Standards are generally based on aesthetic qualities including odor, taste, color, and foaming (EPA 1992). Sulfate is listed for causing a “salty taste” in drinking water. Total dissolved solids are listed for “hardness deposits, colored water, staining, and salty taste.” This effort focuses on sulfate because of the lower Secondary Constituent Standard and because transport is not complicated by sorption. Conclusions drawn from the sulfate results are also likely to apply to other constituents.

Table 2 shows sulfate concentrations in the aquifer from 2008 to 2012. Not surprisingly, the highest concentrations are in the nearest monitoring well (USGS-065) with an average concentration of 160 mg/L (64% of the Secondary Constituent Standard of 250 mg/L). Sulfate concentrations are also elevated in Well TRA-07. Beyond these two wells, the sulfate concentrations in the groundwater dissipate quickly with distance from the CWP. The range of background concentrations for sulfate in the south-central part of the INL Site is approximately 10 mg/L to 40 mg/L (Davis 2010). The local background for sulfate is approximately 24 mg/L based on samples of raw well water (Ashland Inc. 2013), which are pumped from three deep wells (TRA-01, TRA-03, and TRA-04) located near the northeast corner of the ATR Complex, up-gradient from CWP. Sulfate concentrations in Wells USGS-076 and Middle-1823 are slightly above the local background and within the range of background concentrations for the south-central INL.

Table 2. Sulfate concentrations in the aquifer (mg/L) downgradient of the CWP.

Sample Date	Well USGS-065	Well TRA-07	Well TRA-08	Well USGS-076	Well Middle-1823
October 08	160	77.7 ^b	NS ^a	32.1	35.8
April 09	156	155	92.7 ^b	31.7	34.0
October 09	161	157	NS ^a	32.8	34.3
April 10	158	155	47.1	33.2	35.1
October 10	160	155	51.4	32.4	34.3
April 11	160	154	49.4	32.3	34.3
October 11	162	158	49.7	32.8	34.6
April 12	163	160	50.5	33.0	34.1
October 12	162	155	49.5	32.7	35.6
Average	160	156	50	33	35

a. NS = Not Sampled (due to lack of water; dry well).

b. Outlier value not included in average calculation.

10.2 INL Evaluation

10.2.1 Methodology

This evaluation provides a first-level approximation of the potential impact to groundwater from reducing “clean” water discharges to the CWP and concentrating chemicals in the effluent. To assess the impact, relatively simple computer models were used to simulate water flow and sulfate transport from the CWP through the unsaturated zone and underlying aquifer. The models were used to predict sulfate concentrations at the nearest down gradient aquifer monitoring well (USGS-065) used for Idaho IWRP compliance purposes.

Flow and transport through the unsaturated zone was simulated with the one-dimensional Mixing Cell Model (MCM) (Rood 2010); and transport through the underlying aquifer to a down gradient monitoring location was simulated using the two-dimensional GWSCREEN computer code (Rood 2003). GWSCREEN models both the unsaturated zone and aquifer, but does not model transient water fluxes. MCM models transient water fluxes in the unsaturated zone, but does not model flow in the aquifer. Therefore, MCM was used to model the transient water and contaminant fluxes in the unsaturated zone and GWSCREEN was used to model the aquifer. In this case, flow in the aquifer was steady-state, but contaminant transport was transient. By using MCM, the time it takes for contaminants to reach the aquifer and achieve a steady concentration could be estimated.

The overall conceptual model implemented by the MCM and GWSCREEN models is shown in Figure 15. In this case the pond sediment is the surface alluvium above the first basalt contact. Flow and transport through the unsaturated zone is assumed to be one-dimensional. Given the large discharges to the CWP and the existence of perched water bodies below the CWP, the flow is not one-dimensional throughout the entire unsaturated zone. However, the size of the one-dimensional flow column was an approximation between the size of the CWP and the extent of the perched water body. This is discussed in Section 10.2.2.1.1.

MCM outputs both the time-dependent water flux and contaminant fluxes from the base of the model (or any other layer). For this evaluation, the time-dependent sulfate fluxes from MCM were input to a single, very thin unsaturated layer atop the aquifer in GWSCREEN. The size of the unsaturated zone layer in GWSCREEN was the same as the one-dimensional column modeled with MCM.

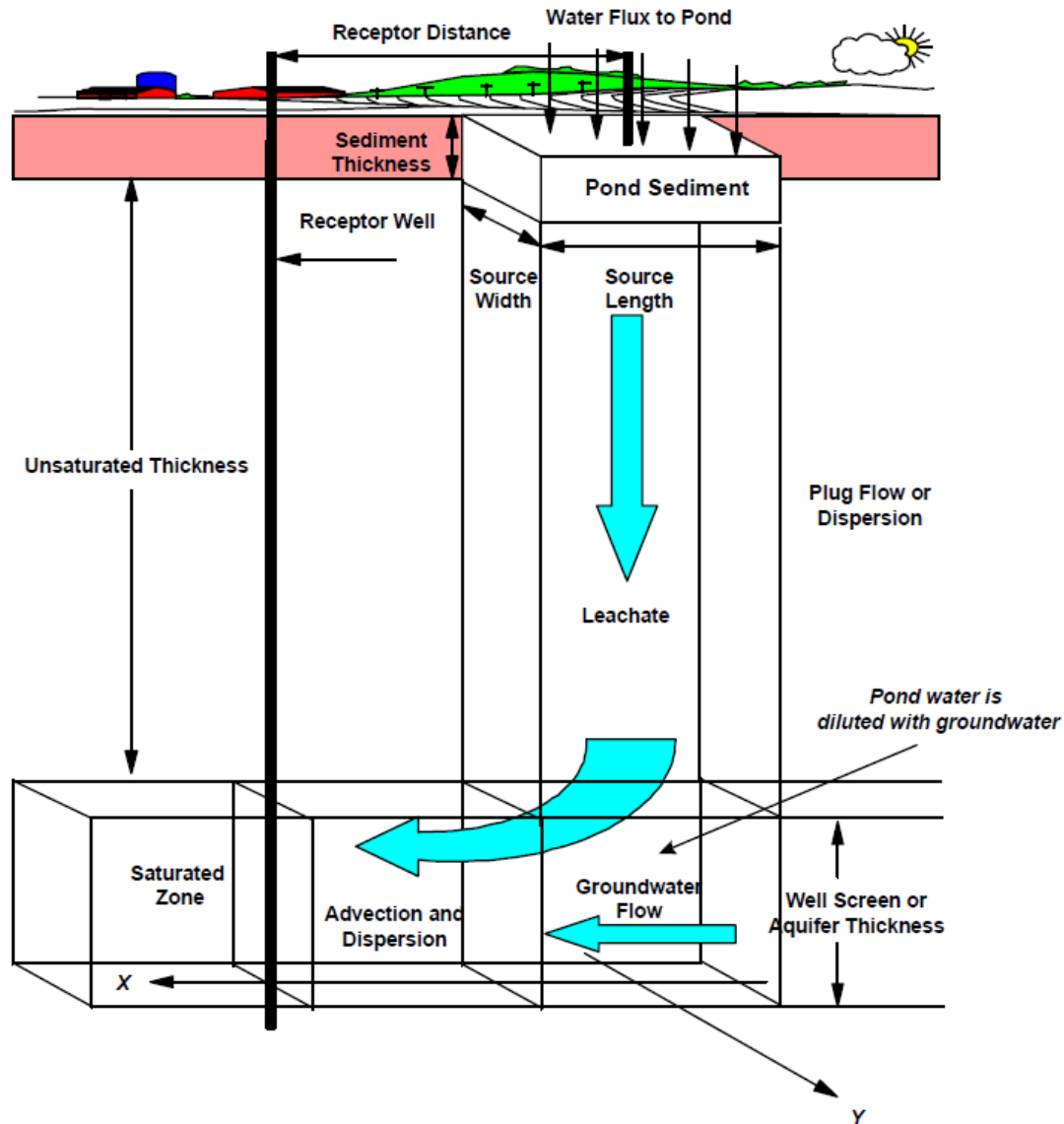


Figure 15. Conceptual model of flow and transport (Source: Rood 2003).

Important parameters needed for this evaluation include pond characteristics (pond size, water discharge rates and sulfate mass loading rates), unsaturated zone characteristics (thickness and flow hydraulic properties of the interbeds and basalt flows), and aquifer characteristics (thickness, groundwater velocity and dispersion properties). Sorption is not considered because sulfate is a conservative contaminant meaning it moves with the water and does not sorb to the rock/soil matrix.

10.2.2 Model Parameterization

10.2.2.1 Cold Waste Pond Characteristics

10.2.2.1.1 Pond Size

The CWP (shown in Figure 16) was constructed as one percolation pond, with two cells, 180 ft (55 m) by 430 ft (131 m) (across the top of the berms) by 10-ft (3.05 m) deep. The bottom (basin) portion of each individual cell is 145 ft (44 m) by 395 ft (120 m) (D. Brett Lewis, personal communication). Discharges between the two cells generally rotate on an annual basis.

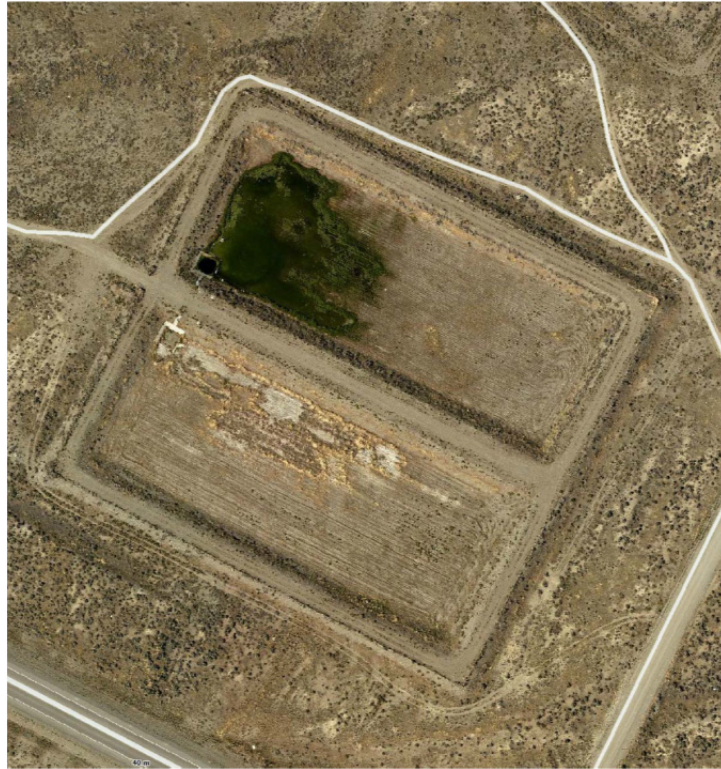


Figure 16. ATR Complex CWP.

Normally when modeling one-dimensional flow from a pond through the unsaturated zone, the dimensions of the pond define the column. However, shallow and deep perched-water bodies have formed in the unsaturated zone at the ATR Complex primarily in response to infiltration of wastewater discharged to unlined ponds (INL 2012). Historically, the CWP, in service since 1982, has been the largest source of water to the perched-water zones. Before constructing the CWP in 1982, the Warm Waste Pond was the principle source of infiltration to the perched-water zones, but operation of the Warm Waste Pond ceased in 1993 when it was replaced with a lined evaporation pond (TRA-715). Discharge to the CWP is currently the largest contributor to the ATR Complex perched-water zone.

Figure 17 conceptually illustrates the development of perched water at ATR Complex. These perched-water bodies developed as the rate of infiltrating water exceeded the capacity of a low-permeability layer to transmit water. Barriers to the vertical migration of water induced a local saturated condition and lateral spreading of the perched water along the top of the low-permeability layer. The deep perched-water zone is much larger in size than the shallow-perched water zone. Figure 18 shows the estimated lateral extent of the deep perched-water zone based on water level measurements in 2003 (DOE-NE-ID 2005), and the average sulfate concentrations in perched-water samples based on samples collected from March 2004 through October 2011. Figure 19 shows deep perched water levels in October 2011. The shape of the deep perched-water zone in 2011 is similar to that of previous maps (RPT-737 2010; RPT-823 2011). However, the October 2011 perched water levels have declined compared to the perched water levels in 2003.

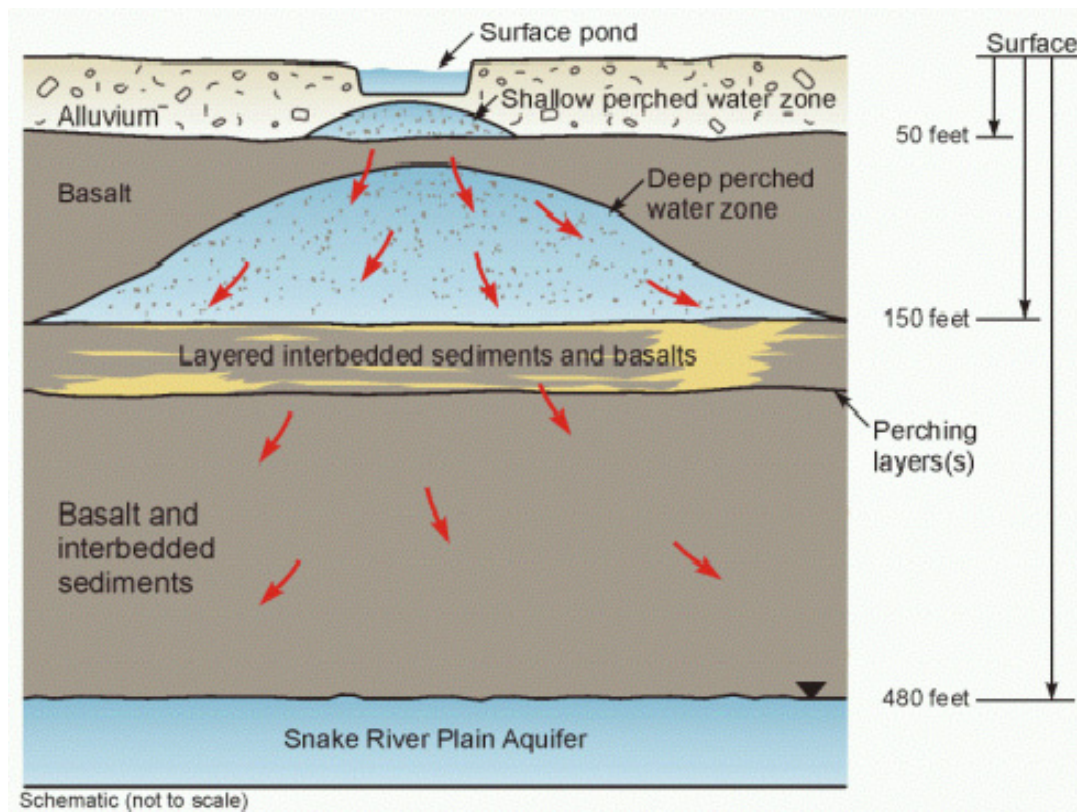


Figure 17. Conceptual diagram demonstrating the formation of shallow and deep perched water zones at the ATR Complex (Source: INL 2012).

As water moves from the CWP through the perched-water zones to the aquifer, the size or “footprint” of the wetted area becomes larger than the infiltration area within the CWP. However, the driving force for vertical water movement is greater where the water levels are deeper. Therefore, for this evaluation a rectangular box larger than the CWP and smaller than the boundary of the deep perched-water zone was chosen to simulate the infiltration area through the unsaturated zone. The area (shown as the red-dashed line in Figure 18) was assigned a width of 1200 m, approximately equal to the width of the 4830-ft contour level in both 2003 and 2011. The length (600 m) was assigned to be half the width to mimic the general width-to-length ratio of the perched water boundary, as shown in Figure 18. The rectangular area was centered in the middle of the CWP and oriented with the long edge parallel to the southwest boundary of the CWP.

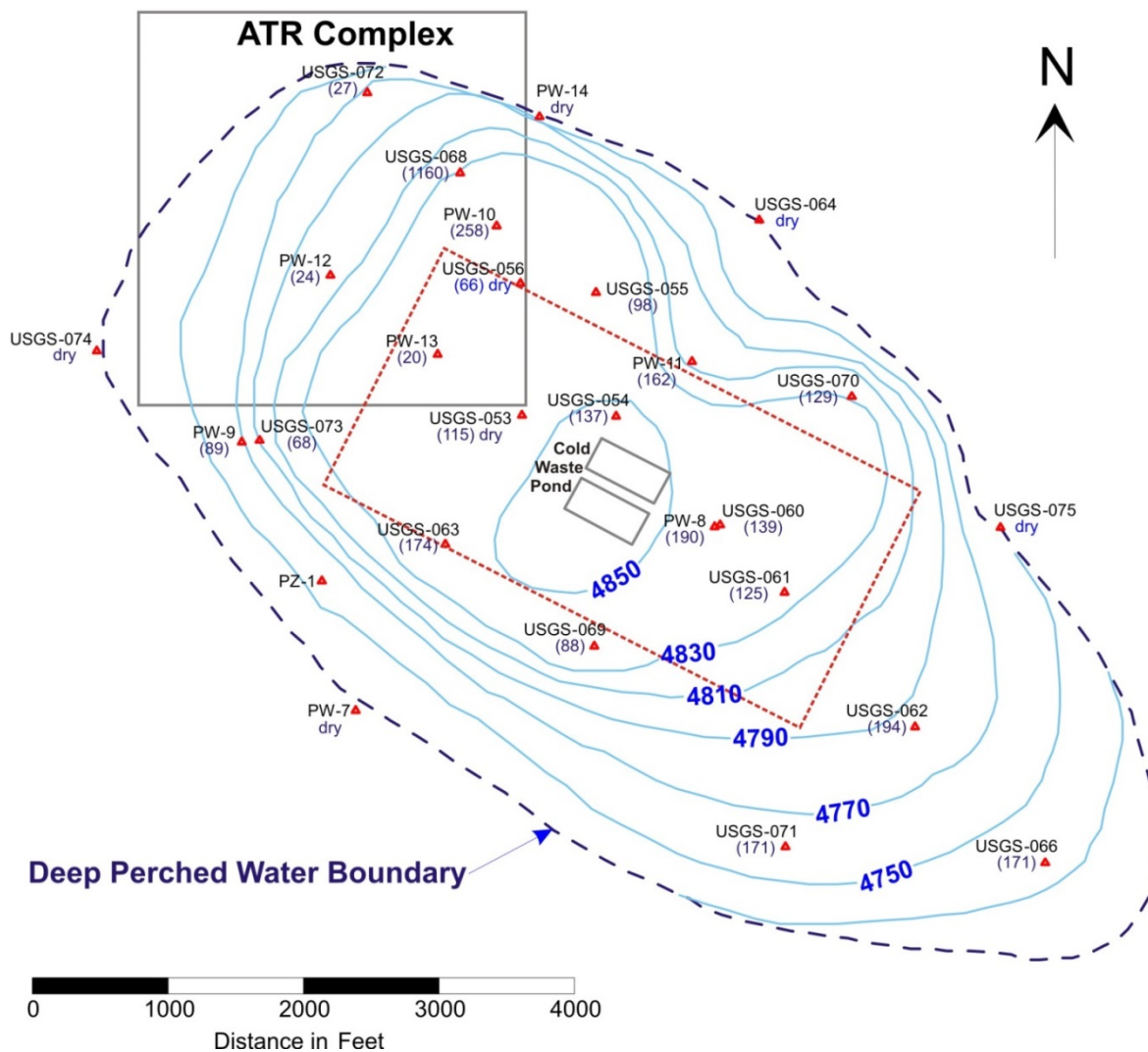


Figure 18. Deep perched water boundary below the ATR Complex CWP based on November 2003 data.

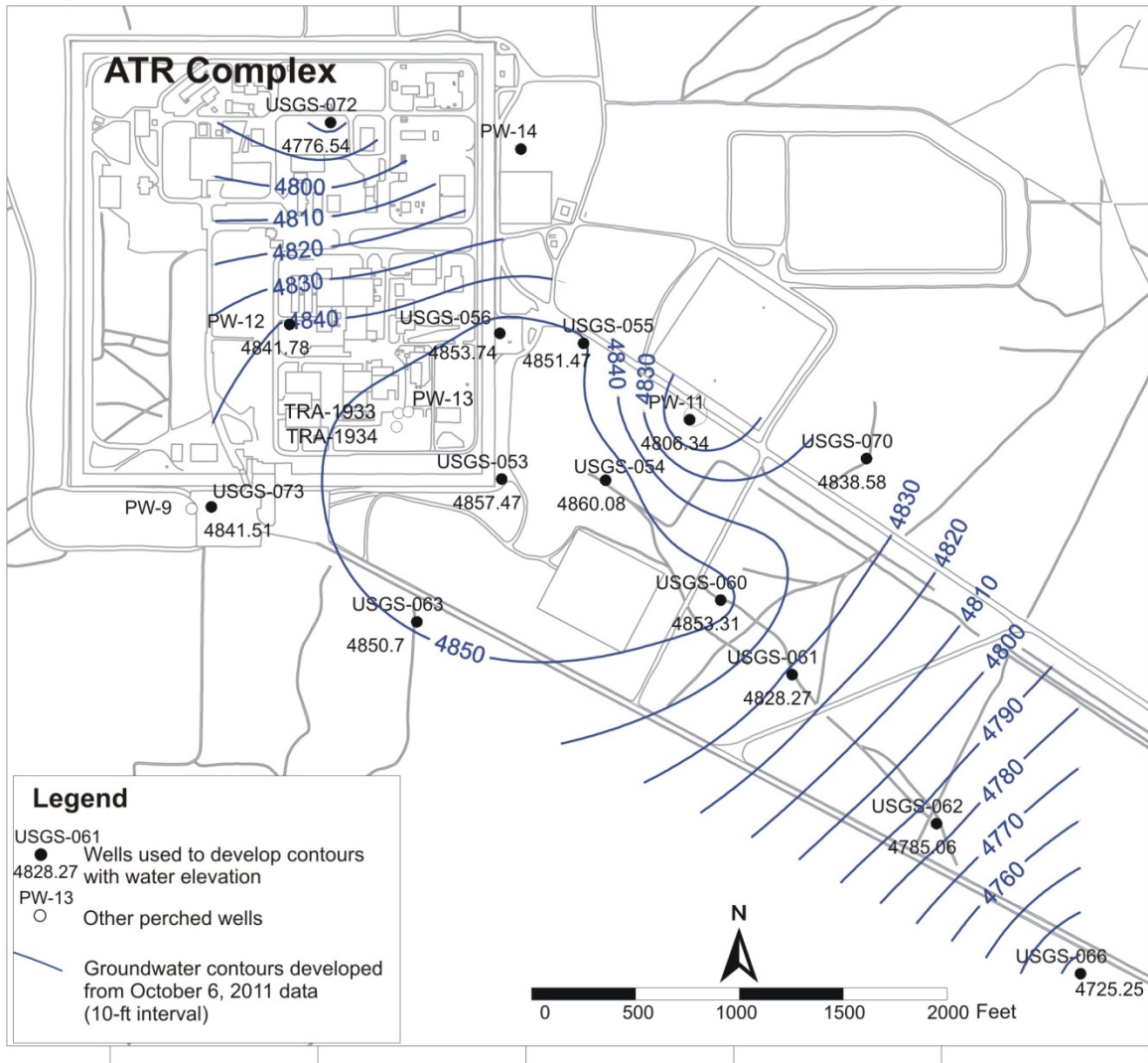


Figure 19. Deep perched water-levels at the ATR Complex in October 2011(Figure source: DOE-ID 2012a).

10.2.2.1.2 Cold Waste Pond Water Discharge

Over the 5-year period from 2008 through 2012, annual discharges to the CWP ranged from a low of 154 M gallons to a high of 202 M gallons, with an average annual discharge of 178 M gallons ($6.75\text{E}+05 \text{ m}^3$) (Data provided by D. Brett Lewis [ATR Programs Infrastructure Manager]). The average annual discharge through the $600 \text{ m} \times 1200 \text{ m}$ area shown in Figure 18 results in a water flux of 0.94 m/yr.

$$(6.75\text{E}+05 \text{ m}^3/\text{yr}) / (600 \text{ m} * 1200 \text{ m}) = 0.94 \text{ m/yr}$$

This is 94 times the background infiltration rate of 1 cm/yr for vegetated undisturbed soils estimated at INL (Cecil et al. 1992). If the total discharge to the CWP is cut by 1/3, the flux is 0.62 m/yr. For a reduction of 1/2, the flux would 0.47 m/yr.

10.2.2.1.3 Cold Waste Pond Mass Loading

Due to the high variability in effluent concentrations, the mass loading was estimated by considering the two primary sources of discharge (blowdown water and other sources). Table 3 shows an estimate of the discharge volumes to the CWP from the various sources for year 2012. This is based on daily flows and the approximate number of days the cooling tower blowdown was established and the approximate number of days auxiliary cooling water was valved to the CWP. Based on this information, the SCS water coming from TRA-771 (ATR Cooling Tower) is 14% of the total CWP discharge volume. The remaining 86% consists of clean well water sources. Based on the average annual flow rate, the SCS and clean water flow volumes are $9.45\text{E}+07$ L/yr and $5.80\text{E}+08$ L/yr, respectively.

$$\text{SCS Water: } 6.75\text{E}+08 \text{ L/yr} * (0.14) = 9.45\text{E}+07 \text{ L/yr.}$$

$$\text{Clean Water: } 6.75\text{E}+08 \text{ L/yr} * (0.86) = 5.80\text{E}+08 \text{ L/yr.}$$

Samples of SCS and raw water from January 5, 2013 show the sulfate concentration in the SCS water is 1279 mg/L and the raw water concentration is 24 mg/L (Ashland Inc., 2013). Using the 5-yr average annual discharge volume, the percentages from Table 3, and the sulfate concentration data from January 2013, the average annual mass loading rate was calculated to be $1.35\text{E}+05$ kg/yr.

$$6.75\text{E}+08 \text{ L/yr} * [1279 \text{ mg/L} * (0.14) + 24 \text{ mg/L} * (0.86)] = 1.35\text{E}+11 \text{ mg/yr.}$$

Table 3. Average annual discharge volumes to the Cold Waste Pond by source.

Cooling Water Source	Average Annual Volume ^a (M gpy)	Percent of Total
TRA-771 Cooling Tower Blowdown ^b	27.6	14%
TRA-670 Auxiliary Equipment ^c	95.0	47%
TRA-609 Air Compressors ^c	42.0	21%
TRA-628 Heat Pumps ^c	31.5	16%
Miscellaneous Equipment Cooling ^c	5.3	3%
Totals	202	100%

a. Data provided by D. Brett Lewis (ATR Programs Infrastructure Manager).

b. SCS water.

c. Clean well water.

When calculating the mass loading for reduced water discharges, it must be kept in mind that only the clean water is being reduced and the volume of SCS water stays the same. For a one-third reduction in total discharge the total discharge volume of clean water is $4.50\text{E}+08$ L/yr.

$$6.75\text{E}+08 \text{ L/yr} * (2/3) = 4.50\text{E}+08 \text{ L/yr.}$$

The percentage of SCS water is then 21%.

$$9.45\text{E}+07 \text{ L/yr} / 4.50\text{E}+08 \text{ L/yr} = 0.21$$

This makes the volume percentage of clean water 79% and the total mass loading is $1.29\text{E}+05$ kg/yr.

$$6.75\text{E}+08 \text{ L/yr} * (2/3) * [1279 \text{ mg/L} * (0.21) + 24 \text{ mg/L} * (0.79)] = 1.29\text{E}+11 \text{ mg/yr.}$$

For a one-half reduction in total discharge, the volume percentages of SCS and clean water are 28% and 72%, respectively, resulting in a total mass loading of $1.27\text{E}+05$ kg/yr.

$$6.75\text{E}+08 \text{ L/yr} * (1/2) * [1279 \text{ mg/L} * (0.28) + 24 \text{ mg/L} * (0.72)] = 1.27\text{E}+11 \text{ mg/yr.}$$

The water discharge and mass loading rates for the different cases examined are summarized in Table 4. Also shown are the average sulfate concentrations in the effluent for the different cases.

Table 4. Summary of water discharge rates, mass loading rates and average sulfate concentrations in the effluent for the three cases examined.

Case Description	SCS Water Volume	Clean Water Volume	Total Water Volume	Sulfate Mass Loading	Average Effluent Conc
	(L/yr)			(kg/yr)	(mg/L)
1. Current discharge (based on 5-yr annual average)	9.45E+07 (14%) ^a	5.80E+08 (86%) ^a	6.75E+08	1.35E+05	200
2. 1/3 reduction in current discharge (reducing clean water only)	9.45E+07 (21%) ^a	3.56E+08 (79%) ^a	4.50E+08	1.29E+05	287 (+44%) ^b
3. 1/2 reduction in current discharge (reducing clean water only)	9.45E+07 (28%) ^a	2.43E+08 (72%) ^a	3.37E+08	1.27E+05	377 (+89%) ^b

a. Numbers in parentheses are % of total discharge.

b. Numbers in parentheses are % increase in concentration from current discharge case.

10.2.2.2 Unsaturated Zone Parameters

The unsaturated zone at ATR Complex is comprised of interlayered basalt flows and sedimentary interbeds. The basalts readily transmit water vertically while the sedimentary interbeds retain water and serve to retard water movement and downward migration of contaminants. Primary sedimentary interbeds have been identified and extensively characterized through activities supporting Comprehensive Environmental Response, compensation, and Liability Act actions at the ATR Complex and at Idaho Nuclear Technology and engineering Center (DOE-ID 1997a; DOE-ID 1997b; DOE-ID 2006; and Helm-Clark et al. 2005). The lateral continuity and variability in sediment thickness near the ATR Complex was evaluated in (INL 2011).

For this evaluation, the stratigraphy from Well USGS-065 was used to construct the unsaturated zone model. Well USGS-065 is the nearest aquifer monitoring well downgradient from the CWP. Table 5 shows the thickness of each layer as implemented in the model.

Table 5. Lithology from Well USGS-065 as implemented in the unsaturated zone model.

Lithologic Description	Modeled as	Top Depth	Bottom Depth	Thickness
		(m)		
Gravel and silt	Alluvium	0.0	18.3	18.3
Basalt/cinders/basalt	Basalt	18.3	46.3	28.0
Clay and basalt	Sediment	46.3	50.6	4.3
Basalt	Basalt	50.6	64.0	13.4
Sand/clay/cinders	Sediment	64.0	71.3	7.3
Basalt	Basalt	71.3	89.9	18.6
Cinders and clay	Sediment	89.9	93.0	3.0
Basalt	Basalt	93.0	100.6	7.6
Clay	Sediment	100.6	102.4	1.8
Basalt/cinders	Basalt	102.4	144.8	42.4
Total		NA	NA	145

Hydraulic properties describing the relationship between water content, capillary pressure and hydraulic conductivity for alluvium and sedimentary interbeds were taken from DOE-ID (2006). The basalt properties were taken from Magnuson (1995). The values are shown in Table 6.

Table 6. Hydraulic properties assigned to the different material types representing the geostratigraphy.

Material	Saturated Hydraulic Conductivity (m/yr)	Total Porosity	Residual Moisture Content	Van Genuchten Fitting Parameter n	Van Genuchten Fitting Parameter α (1/m)	Van Genuchten Fitting Parameter m	Van Genuchten Fitting Parameter L	Bulk Density (g/cm ³)
Alluvium ^a	8798	0.32	0.0002	1.4	100	0.29	0.5	1.82
Interbed ^a	1040	0.6	0.11	1.29	10.5	0.22	0.5	1.34
Basalt ^b	91	0.05	0.001	10	2.5	0.9	0.5	2

a. From DOE-ID (2006).

b. From Magnuson (1995).

The total thickness of the unsaturated zone model is 145 m and the domain was discretized into 100 layers, each 1.45 m thick. No additional dispersivity was assigned to the unsaturated zone model other than the implicit dispersion inherent in the MCM code. The amount of implicit dispersion is approximated by the number of cells and the length of the model domain or total unsaturated thickness.

$$\alpha_L = Z / 2n$$

where α_L = the longitudinal dispersivity (m), Z = unsaturated zone thickness (m), and n = the number of cells. For all MCM simulations, 100 cells were used. So, for an unsaturated thickness of 145 m, the value of α_L is 0.725 m.

10.2.2.3 Aquifer Parameters

For this evaluation, transport in the aquifer was calculated using a two dimensional semi-analytical solution to the advection-dispersion equation in groundwater as implemented in GWSCREEN where the concentrations are vertically averaged over a well screen thickness of 15 m (DOE-ID 1994). A constant water flux and a time-dependent sulfate flux from MCM were input to the 600 m × 1200 m source area (see Section 10.2.2.1.1). This source area was a very thin (0.001 m) unsaturated layer placed atop the aquifer model centered in the middle of the CWP. Sulfate concentration as a function of time was calculated at Well USGS-065 located 470 m from the center of the source parallel to the direction of groundwater flow and 230 m from the center of the source perpendicular to the direction of groundwater flow (see Figure 20). The direction of groundwater flow was assumed to be perpendicular to the southwest boundary of the CWP (see Figure 14).

Groundwater flow velocity, porosity, and dispersivity values were taken from a comprehensive sub-regional modeling study of the Snake River Plain Aquifer (DOE-ID 2008). The aquifer Darcy velocity was assigned a value of 16 m/yr, and the porosity was assigned a value of 0.06. The velocity is an average value of velocities in the vicinity of the ATR Complex as explained in DOE-ID (2012b). The longitudinal, horizontal transverse and vertical transverse dispersivity values were assigned values of 91 m, 40 m, and 4.6 m, respectively (DOE-ID 2008). However, the vertical dispersivity is much less important because the contaminant is confined to the upper 15 m of the aquifer and likely to be well mixed by the time it reaches the Well USGS-065 location.

10.2.2.4 Other Modeling Considerations

The unsaturated zone model was run for a period of 50 years to allow concentrations in the aquifer to reach a pseudo-steady condition. While the unsaturated zone transport calculations account for transients, the GWSCREEN calculations assume steady-state flow conditions. However, the discharge flux from the unsaturated zone to the aquifer is an important factor in controlling the concentrations within the aquifer, and GWSCREEN incorporates algorithms to include the effect of dilution associated with mixing of vertical recharge with groundwater through flow. Because the vertical water flux from the CWP was considered large compared to the groundwater through flow, the dilution option (IDIL=2) was implemented in GWSCREEN.

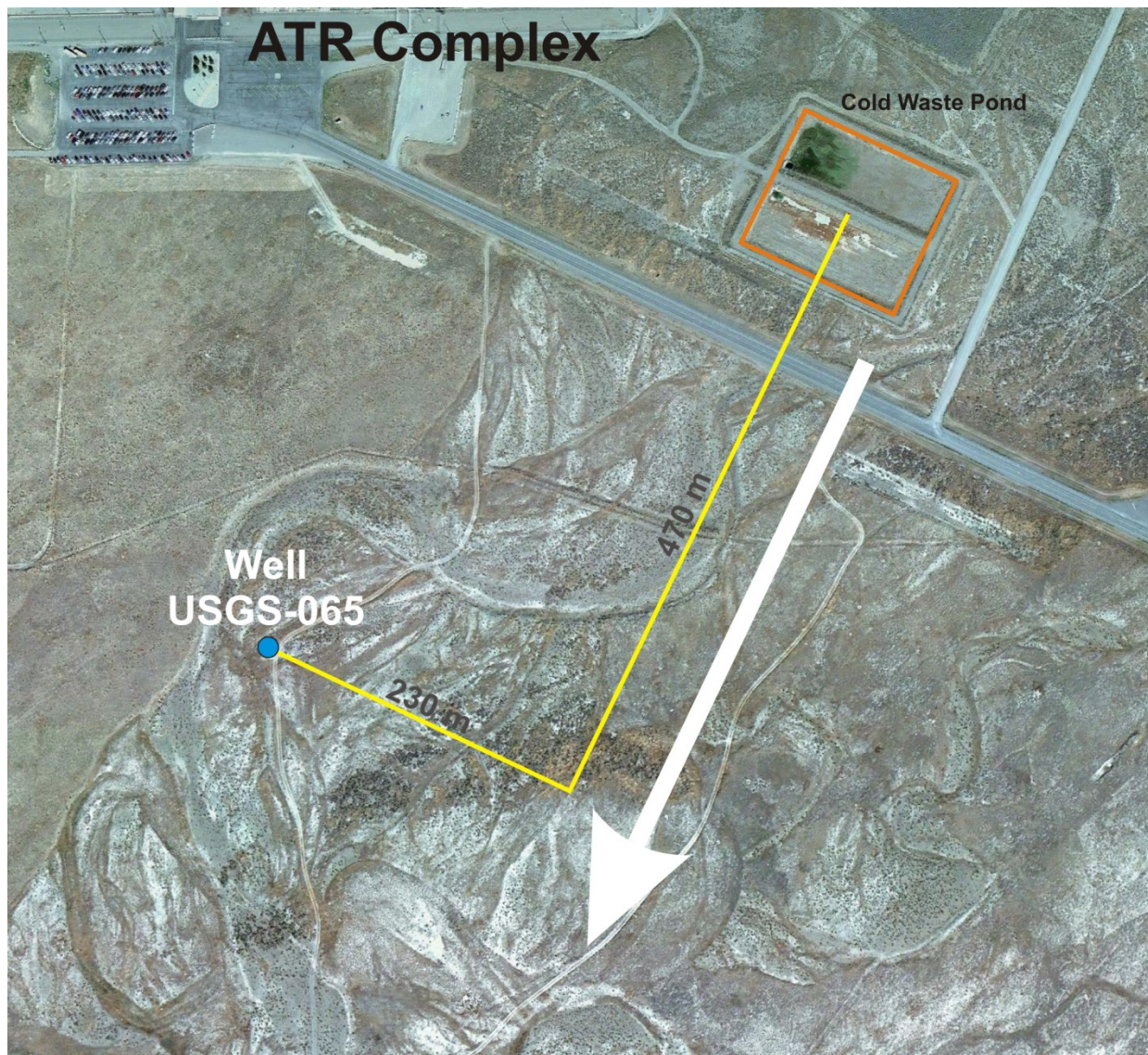


Figure 20. Location of Well USGS-065 relative to the CWP showing distances along and transverse to the inferred flow direction. Groundwater flow direction indicated by the large white arrow. Base map courtesy of Google Earth, (2013).

10.3 Results

Sulfate concentrations as a function of time are presented in Figure 21 for all three cases examined: (1) current discharge, (2) 1/3 reduction in current discharge by reducing clean water, and (3) 1/2 reduction in current discharge by reducing clean water. The aquifer background concentration of 24 mg/L was added to all model predicted concentrations since the model assumes a clean aquifer with respect to sulfate. For the current discharge case where the water volumes and mass loading rates are based on current values, the maximum sulfate concentration at Well USGS-065 is predicted to be 156 mg/L. This is slightly less than the average concentration of 160 mg/L (see Table 2). The fact that the predicted concentrations match the measured concentrations reasonable well provides confidence that the model is appropriate.

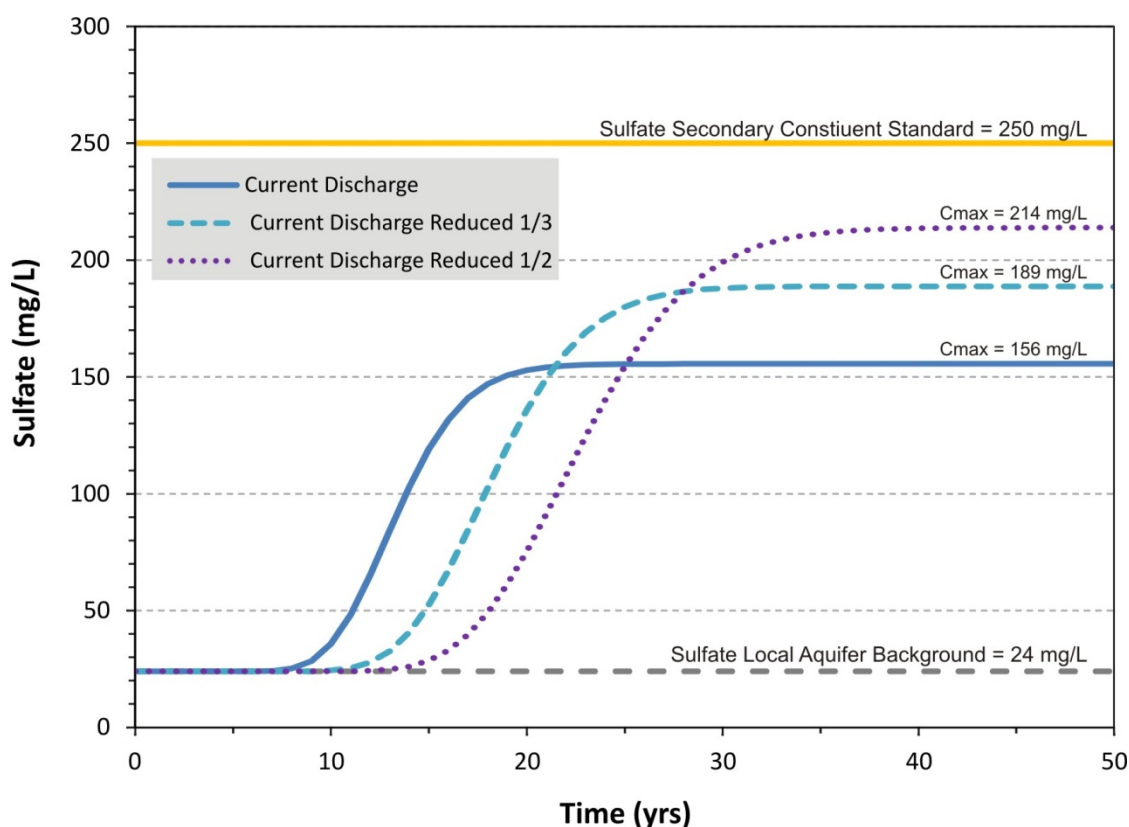


Figure 21. Model predicted sulfate concentration as a function of time at the Well USGS-065 location for the three scenarios examined.

The results indicate that for the case where the current discharge is reduced by 1/3, the maximum predicted sulfate concentration is 189 mg/L. Although the effluent concentration for this case would increase 44%, the maximum predicted aquifer concentration increased only 21% over the current discharge case. For the final case where the current discharge is reduced by 1/2, the maximum predicted sulfate concentration is 214 mg/L. Although the effluent concentration for this case would increase 89%, the maximum predicted aquifer concentration increased only 37% over the current discharge case.

The results of this evaluation indicate that reducing the volume of clean water discharged to the CWP will increase sulfate concentrations in the aquifer, further degrading the ground water quality. However, it is not expected to increase concentrations at IWRP compliance monitoring Well USGS-065 above the Secondary Constituent Standard of 250 mg/L. The maximum discharge reduction evaluated in this study (one-half the total current discharge volume) increased the concentration from a baseline prediction of 156 mg/L to 214 mg/L.

10.4 INL Implementation Cost Estimate

There is no cost impact associated with reducing the amount of water being sent to the CWP. However, implementing options, such as modifying the air compressor cooling water discharge described in Section 9, to divert water from the CWP has a cost impact and will require a detailed cost estimate prior to implementing. These costs have been identified in their related sections of this report. No cost estimate was performed specifically for this evaluation.

10.5 INL Recommendations

While the modeling performed for this evaluation estimates reducing the volume of “clean” wastewater discharged to the CWP by as much as ½ will not cause the sulfate Secondary Constituent Standard to be exceeded in the aquifer downgradient of the CWP, the reduced discharge is predicted to worsen the impact on the groundwater quality. The IDEQ considers wastewater to have a negative impact on groundwater if a constituent is 10% of the Secondary Constituent Standard above background and the well monitoring currently demonstrates a negative impact. Though this evaluation focused primarily on sulfate, sulfate is not the only constituent of concern. It is possible that other constituent concentrations in the aquifer may increase in a similar manner as sulfate.

INL recommends consideration of long-term water conservation measures that divert “clean” wastewater from the CWP to the sewage lagoon and any other water conservation measures around the ATR Complex as funding and project prioritization allow. Even though the sulfate SCS are not exceeded, the Idaho IWRP requires compliance with the Idaho Groundwater Quality Standards. Thus, modifications that are projected to further degrade groundwater quality should be reviewed by IDEQ prior to implementation.

11. REDUCE DESERT PURGE FLOW RATE

INL Recommendation 5

11.1 Description

Raw water for the ATR Complex is supplied from the aquifer by the three operating deep wells (TRA-01, TRA-03, and TRA-04). Deep Well TRA-02, located in building TRA-602, was abandoned in the 1970s due to alignment difficulties and its poor location. The motor for Deep Well 2 was removed, the pump left in place, and the well casing sealed with grout. A 10-in. line is connected to the pump discharge piping in building TRA-602 and runs north, under Tarpon Avenue into a culvert that empties into a drainage ditch outside the Complex (see Figure 22). This line is referred to as the “Desert Purge” and was originally installed so operations personnel could control the water level in the raw water ground level storage tanks in the event the deep well pumps needed to be operated in manual mode.



Figure 22. Drainage ditch.

This Desert Purge line has been periodically used in the last 10 to 15 years to control the water level in the ground level storage tanks to reduce the on/off cycling of the deep well pumps and to provide drinking water for big game animals outside the complex in an attempt to lure the big game away from the waste ponds. The practice of using the desert purge line to keep the pumps from cycling has been discontinued, but the use of this line to provide water for the big game has continued. The Desert Purge is typically established in the spring and secured in the fall. There is no written policy with duration and flow requirements established for using the Desert Purge for big game watering. Therefore, conservative numbers were used in this evaluation to estimate potential savings.

It is proposed to cut this water flow from 250 gpm to 100 gpm for the 6 month period. It is estimated this would still provide sufficient water for the big game.

11.2 INL Evaluation

According to operations personnel the Desert Purge is typically established each year for approximately 6 months. The flow rate is controlled by an operator manually turning the gate valve. There is no set flow or duration formally established. Even though a flow meter is located in the 10-in. Desert Purge line, it cannot be used to measure flow as this type of meter requires the pipe to be full of water to operate properly.

Engineering evaluated the pipe size, valve type, and head pressure to estimate flow rate based on valve disk position (i.e., valve stem height). The gate valve positions are shown in Figure 23 and the flow rate results as a function of valve position are shown in Figure 24.

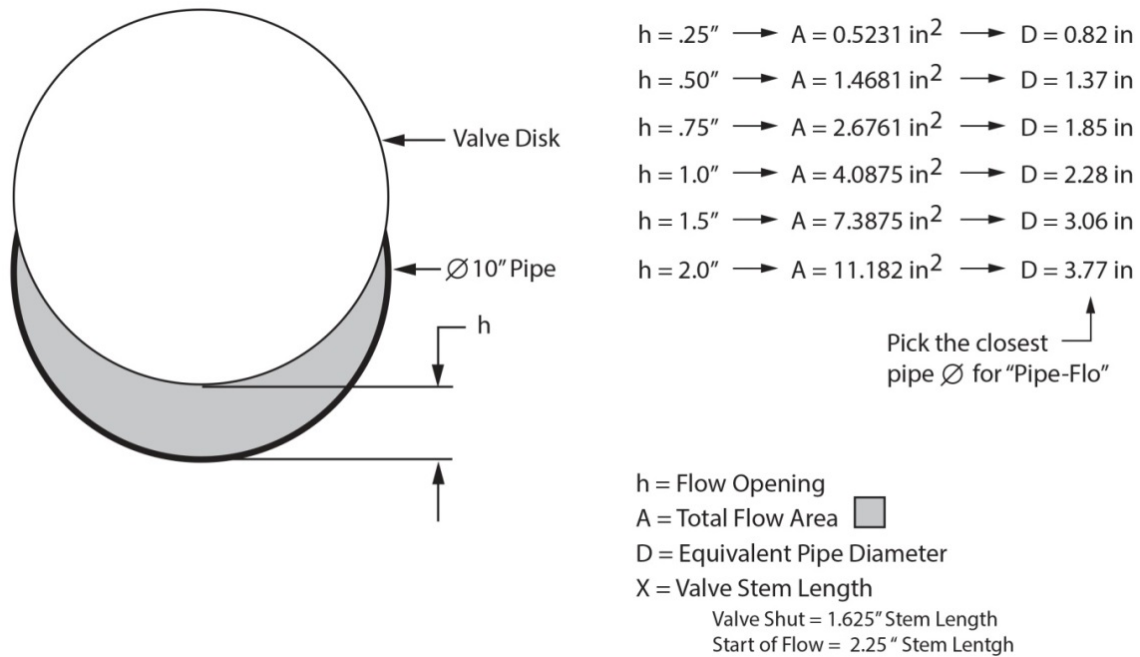


Figure 23. Valve disk positions for determining flow rate for the Desert Purge line.

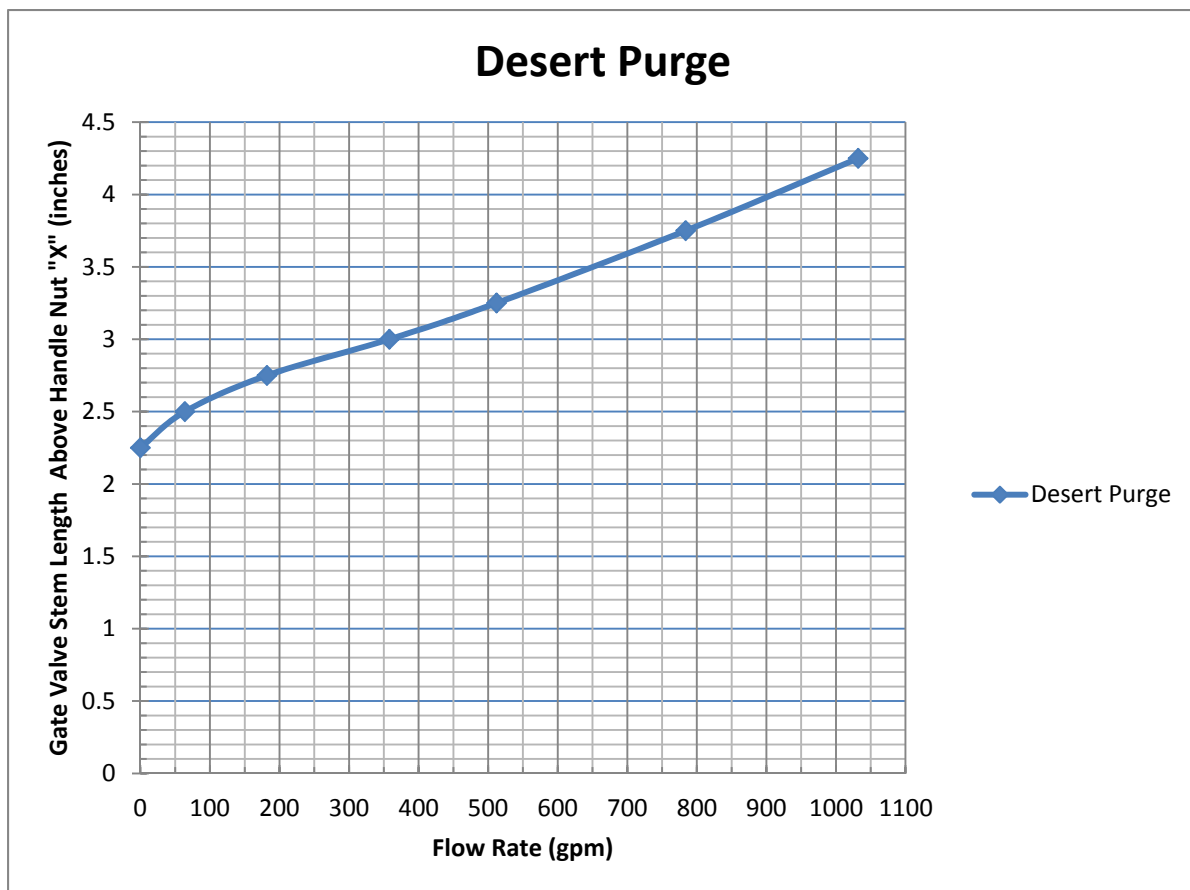


Figure 24. Calculated flow rate based on valve stem height for the Desert Purge line.

As part of this evaluation, an operator was asked to open the 10-in. gate valve as if they were establishing Desert Purge flow in the spring. After flow was established, the length of the valve stem was measured and found to be 2.875-in. above the hand wheel nut (see Figure 25). An estimated flow of 250 gpm was determined using the graph in Figure 24. Assuming that the Desert Purge operates for 6 months at a flow of 250 gpm, total water usage is approximately 66 M gallons. Reducing the flow down to 100 gpm would yield an annual water consumption of 26 M gallons, thus reducing the water consumption by 40 M gallons.



Figure 25. Desert purge valve wheel showing the height of the wheel nut for typical conditions.

11.3 Benefits and Concerns

The benefits of implementing this strategy include a significant reduction in water usage as well as the elimination of deep well run times, thereby reducing electrical costs.

The concerns of implementing this strategy would be the water could soak into the ground if the flows are reduced too much, possibly rendering the ditch unusable for animals looking for water. If implemented the reduced flow would be monitored and evaluated to determine if the reduced flow rate is enough to maintain water in the ditch.

11.4 INL Implementation Cost Estimate

There is no cost associated with implementing this proposal. Reducing water discharges to the desert to provide water for big game animals has no cost impact. However, a change in management practice is required. No cost estimate was performed.

11.5 INL Recommendations

Reducing the Desert Purge flow rate from 250 gpm to 100 gpm should continue to provide adequate drinking water for big game animals while reducing the water usage at the ATR Complex by approximately 40 M gallons each year. Based on an energy cost of \$0.0007 per gallon, the energy savings would be \$28,000 per year.

Due to the ease of implementation and the low cost associated with this strategy, ATR Programs Infrastructure recommends that a policy be implemented to reduce the flow rate and limit the duration to 6 months when the Desert Purge is established.

12. XERISCAPE INSTALLATION AT THE ATR COMPLEX

INL Recommendation 6

12.1 Description

Xeriscaping is the practice of designing landscapes to reduce or eliminate the need for irrigation. This means xeriscaped landscapes need little or no water beyond what the natural climate provides. Xeriscaping has been embraced in dry regions of the western United States and is being considered for installation around the ATR Complex on a limited basis. Simply paving over an area with asphalt or concrete, letting the grass die, or installing nothing but rock is not xeriscaping. Xeriscaping means replacing grassy lawns with soil, rocks, mulch, and drought-tolerant native plant species.

Limited xeriscaping activities have occurred in and around INL. At the Center for Advanced Energy Studies, native vegetation was used as part of the Leadership in Energy and Environmental Design certification. At CFA, limited experimentation was done to remove grassy areas and replace with gravel and native plants. Aesthetic and safety impacts are always considered prior to any xeriscaping installation decision. In the future, newer facilities will all require the use of the xeriscaping concept.

At the ATR Complex, three areas are being considered for xeriscaping installation: two on the southern-most area of the complex and one on the eastern most edge of the complex. These are considered remote and xeriscape implementation would have minimal interference with daily operations. Figure 26 displays the three areas being considered for xeriscaping activities.

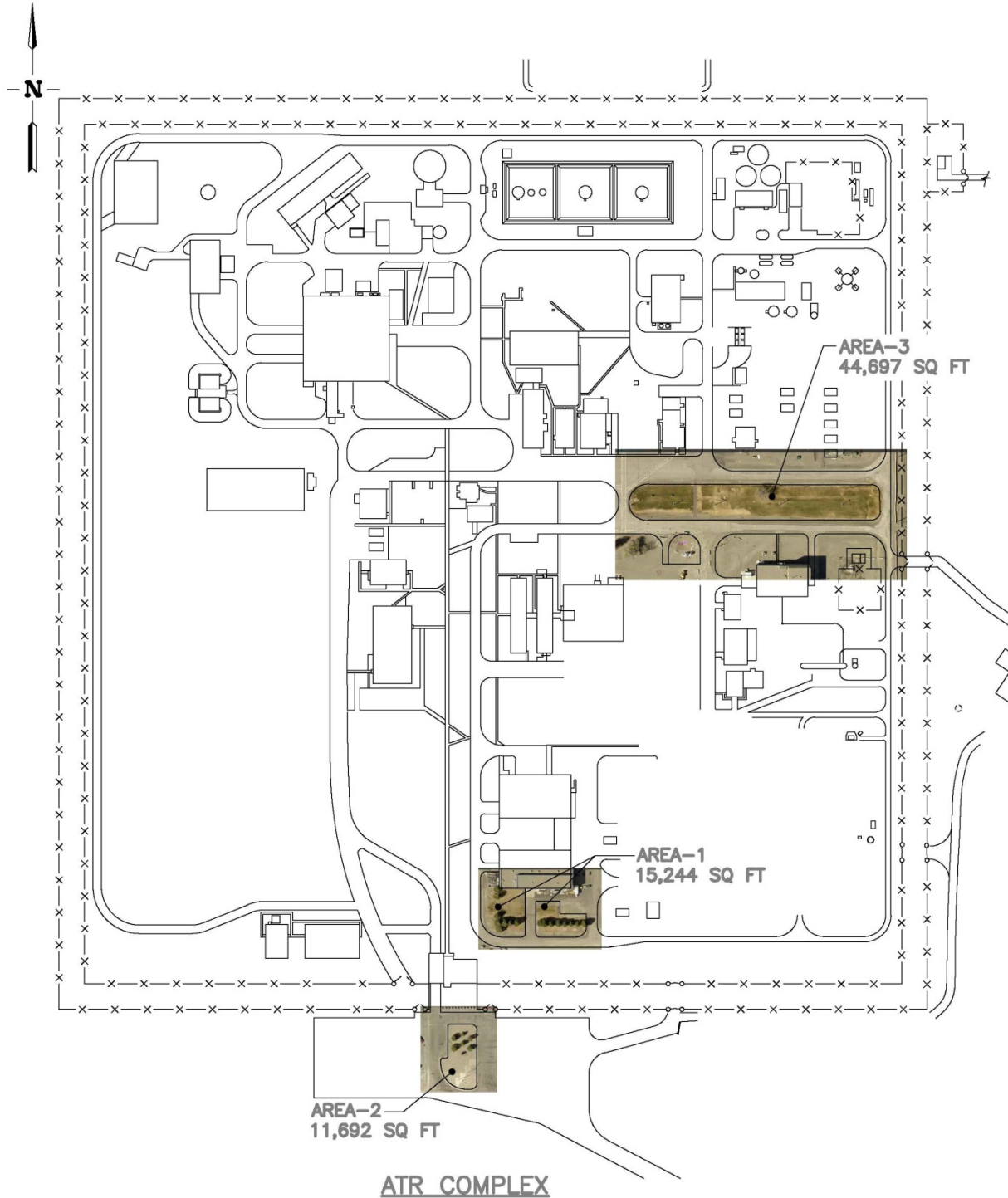


Figure 26. ATR Complex plan view showing areas considered for xeriscaping.

12.2 INL Evaluation

The three areas being considered for xeriscaping are a combined 71,633 ft² of space for consideration. A preliminary cost estimate was performed and the total cost for all three areas is \$480,000. A detailed cost estimate will be prepared if the decisions made to move forward with installation.

Based on water meter readings on the irrigation system, the current ATR Complex water consumption is 14.2 M gpy for 9.2 acres. Area 2 in Figure 26 does not have any grass; therefore, it is not sprinkled. That area does consume water for the trees planted there. It is assumed that the net reduction of water for this area will be zero. Water reduction will occur in Areas 1 and 3. The total size for the two areas is 1.38 acres. It is estimated that 2.13 M gpy would be reduced by eliminating sprinklers. However, there are 16 trees located in the two areas that require watering. Based on each tree requiring 15 gallons of water per day during the 5 month watering season, it is estimated that 36,000 gpy is required to water trees. Thus, the resulting water savings will be 2.1 M gallons yearly. With an energy cost of \$0.0007 per gallon, it is estimated that \$1,466 per year will be saved.

12.3 INL Cost Estimate

An INL cost estimate was prepared to perform the design and construction for the proposed work. This preliminary cost estimate provided a range of:

- A low end value of \$300,000

- A targeted point value of \$477,000

- A high end value of \$620,000

See Attachment 9, “ATR Water Study–Xeriscape Installation at the ATR Complex,” for a summary level report of the target point value. A detailed cost estimate will be required to obtain funding if it is decided to implement this proposed measure.

12.4 INL Recommendation

As INL moves toward more water conscious operations, this option provides water savings and the opportunity to change an ingrained culture. Once safety aspects are approved and funding obtained, this option should be fully implanted as a test case for other areas at the ATR Complex and throughout the INL Site.

13. CONCLUSION AND RECOMMENDATIONS

In FY 2011, PNNL performed an assessment of INL water consumption at the ATR Complex. In particular, the assessment focused on the ATR Complex because of its increasingly high water use. The report, “Idaho National Laboratory Water Assessment” (PNNL-21288), identified four water savings measures and included potential water savings, energy savings, and implementation costs. INL reviewed each PNNL proposal and performed an independent technical evaluation.

This technical evaluation report, “INL Assessment of PNNL Water Conservation Study for the ATR Complex” (INL/EXT-13-29045) addresses each proposal and identifies six alternative INL water savings opportunities. Table 7 summarizes the four PNNL water saving measures, the INL evaluation of the PNNL measures, and the six additional INL proposed water saving measures.

Table 7. Water savings proposals summary.

Proposal	Water Savings (M gpy)		Energy Savings (\$K/yr)		Implementation Costs (\$K)	
	PNNL	INL	PNNL	INL	PNNL	INL
Utilize Cooling Tower Blowdown Control (PNNL-1)	6.0	Note 1	0.7	Note 2	5.7	90.0
Replace Inorganic PO ₄ Scale/Corrosion Control Chemistry (PNNL-2)	17.2	5.5	2.1	3.2	5.7	243
Auxiliary Cooling Water Supply to ATR During Outages (PNNL-3)	49.4	Note 1	6.0	Note 2	35.6	1,91.0
Dry-Fluid Cooling to Replace Once-Through Air Compressor (PNNL-4)	44.7	Note 1	5.4	Note 2	67.3	2,229
ATR Sewage Lagoon Options	Note 3	12	Note 3	8.4	Note 3	574 Note 4
TRA-609 Air Compressor Cooling Water Discharge Modification	Note 3	14	Note 3	9.8	Note 3	35.0
TRA-628 HVAC Control System Modification	Note 3	5	Note 3	3.5	Note 3	314.0
ATR Cold Waste Pond Evaluation	Note 3	Note 5	Note 3	Note 5	Note 3	0
Reduce Desert Purge Flow Rate	Note 3	40	Note 3	28	Note 3	0
Xeriscape Installation at the ATR Complex	Note 3	2.1	Note 3	1.47	Note 3	477.0

Note 1: The INL did not disagree with the water savings calculation.

Note 2: The INL did not disagree with the energy savings calculation.

Note 3: The PNNL Report did not consider the proposal.

Note 4: This cost estimate is for fence installation; an optional part of the proposal.

Note 5: This is an evaluation to identify if water reduction measures, such as the TRA-609 Air Compressor Cooling Water Discharge Modification can be implemented. No identified water savings.

Following a detailed analysis and preliminary Level 5 cost estimate, INL determined that the PNNL implementation cost estimates were under estimated. Based on the INL implementation cost estimates, it is likely that PNNL considered only the installation costs. The PNNL report did not provide or reference a basis for their implementation cost estimates so it can only be assumed what their basis and considerations were. The four PNNL proposals identified a significant amount of water savings. However, based on the implementation costs developed by INL and the operational and technical concerns identified by INL, it is INL’s position that none of the PNNL proposals are feasible.

PNNL Proposals 1 and 2 require additional and extensive evaluations to justify implementation. These two proposals recommend changing the ATR SCS water chemistry and cooling tower blowdown operating philosophy to reduce water consumption. Changing water chemistry or the cooling tower blowdown frequency could adversely affect the integrity of the heat exchangers and the secondary cooling system. The current water treatment has been successful for decades, and prior to making any changes a detailed evaluation must be performed to determine the impact to the equipment and hardware associated with the SCS.

PNNL Proposal 3, “Auxiliary Cooling Water Supply for ATR HVAC during Outages,” recommends installation of a new system what will pump SCS water from the cooling tower basin to TRA-670 during ATR outages. Technically, this proposal is possible but not practical for three reasons. First, this option introduces potential contaminated water that could accelerate corrosion of reactor equipment and heat exchangers. Second, there is very limited physical space available to install the additional equipment and piping required to implement this option. Third, based on INL cost estimates, PNNL underestimated the implementation cost. Assuming the INL cost estimate is more realistic, this option is not cost effective.

PNNL Proposal 4 would replace the once-through cooling water servicing the air compressors in TRA-609 with a skid-mounted dry-fluid cooling system. It appears that PNNL under estimated the implementation cost, thus making it not cost effective when the more realistic INL estimated costs are applied to the proposal. Also, because of the congestion of the building and the surrounding area, it would be very difficult to install the required equipment.

Of the additional six water-saving measures identified and analyzed, INL recommends implementing the following proposals:

1. “Reduce Desert Purge” immediately, thus reducing water consumption by 40 M gallons per year.
2. The “Eliminate Sewage Lagoon Supplemental Water” option should be implemented as soon as possible. The “Eliminate Sewage Lagoon Supplemental Water” option includes the cost of installing a barrier fence. While installation of the fence is recommended to help avoid damage to the lagoon liner by wildlife, it is not mandatory. The J-U-B, Inc. Sewage Lagoon Report states that water does not need to be diverted to the sewage lagoon to maintain a water cap. The report identified that there is an adequate amount of water discharged to Cell 1 for proper operation and that Cell 2 does not require a water cap. Therefore, diverting air compressor cooling water, or any other diversion, to the sewage lagoon is not required or desired under the current conditions. This option would yield a water reduction of nearly 55 M gallons annually with no implementation cost.
3. INL recommends modifying the TRA-628 HVAC control system as funding and project prioritization allow. By modifying the control system, nearly 5 M gallons of water can be eliminated, operational efficiencies realized, and system components upgraded to modern standards. Implementing this recommendation will reduce water to the CWP, so can only be implemented if approved and reviewed by IDEQ because of the potential impact the ground water quality.

Finally, INL recommends considering the TRA-609 Air Compressor Cooling Water Discharge and Xeriscaping as funding and project prioritization allow. The modification to the TRA-609 air compressor cooling water would allow facility personnel to redirect water to the sewage lagoon if needed. Based on the J-U-B report, at this point in time the diversion of water to the sewage lagoon is not required. Modifications that reduce “clean” wastewater to the CWP should only be implemented if approved and reviewed by IDEQ since the ATR CWP evaluation determined that reducing “clean” wastewater will further degrade ground water quality. The water reduction obtained by implementation of xeriscaping is not necessarily cost effective.

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Attachment 1

ATR Water Study – INL Cost Estimate: Utilize Cooling Tower Blowdown Control

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Project Summary Report

Project Name: **ATR Water Study Option E - Automated Cooling Tower Blowdown**
 Project Location:
 Estimate Number: **ATR 7B63-E**

Client: **K. F. Hassing**
 Prepared By: **E. J. Behunin**
 Estimate Type: **Unable to Classify**

<u>Level</u>			<u>Estimate</u>		<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
1.0	OPC	<u>Project Development</u>	\$5,400	\$0	\$1,620	30.00%	\$7,020
2.0		<u>Project Management</u>	\$5,000	\$0	\$1,500	30.00%	\$6,500
3.0		<u>Preliminary/Final Design</u>	\$11,792	\$0	\$3,538	30.00%	\$15,330
4.0		<u>AE Support</u>	\$1,398	\$0	\$419	30.00%	\$1,818
5.0		<u>Execution Phase</u>	\$14,670	\$0	\$4,401	30.00%	\$19,072
5.1		.... Program Execution	\$10,112	\$0	\$3,033	30.00%	\$13,145
5.1.1		..... BEA Direct Hire Construction (In House)	\$10,112	\$0	\$3,033	30.00%	\$13,145
5.1.1.1		..... General Requirements	\$3,626	\$0	\$1,088	30.00%	\$4,714
5.1.1.2		..... Blowdown Controls	\$6,486	\$0	\$1,946	30.00%	\$8,431
5.1.2	OPC	.... Work Orders (WOs)	\$4,559	\$0	\$1,368	30.00%	\$5,927
5.1.2.1	OPC	..... Prepare WO	\$4,559	\$0	\$1,368	30.00%	\$5,927
6.0		<u>BEA Support of Construction</u>	\$7,293	\$0	\$2,188	30.00%	\$9,480
7.0		<u>Training</u>	\$9,064	\$0	\$2,719	30.00%	\$11,783
8.0		<u>Procedure Revisions</u>	\$10,895	\$0	\$3,269	30.00%	\$14,164
9.0	OPC	<u>Project Transition/Closeout Phase</u>	\$2,700	\$0	\$810	30.00%	\$3,510
Total ATR Water Study Option E Automated Blowdown Controls			\$68,212	\$0	\$20,464	30.00%	\$88,676

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Cost Estimating

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Attachment 2

ATR Water Study – INL Cost Estimate: Replace Inorganic PO₄ Scale/Corrosion Control Chemistry

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Project Summary Report

Project Name: **ATR Water Study - Corrosion & Scale**

Client: **K. F. Hassing**

Project Location: **INL - ATR**

Prepared By: **E. J. Behunin**

Estimate Number: **7B63-G**

Estimate Type: **Project Support - Unclassifiable**

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
01	OPC	<u>Material Compatability Analysis</u>	\$80,000	\$0	\$28,000	35.00%	\$108,000
02	OPC	<u>Biocide Analysis</u>	\$30,000	\$0	\$10,500	35.00%	\$40,500
03	OPC	<u>Modifications Cost/Benefit Analysis</u>	\$30,000	\$0	\$10,500	35.00%	\$40,500
04	OPC	<u>Water Savings Analysis</u>	\$20,000	\$0	\$7,000	35.00%	\$27,000
05	OPC	<u>Implementation Plan</u>	\$20,000	\$0	\$7,000	35.00%	\$27,000
Total ATR Water Study - Corrosion & Scale			\$180,000	\$0	\$63,000	35.00%	\$243,000

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Cost Estimating

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Attachment 3

ATR Water Study – INL Cost Estimate: Auxiliary Cooling Water Supply for ATR HVAC during Outages

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Project Summary Report

Project Name: **ATR Water Study/Provide Auxiliary Cooling Water Supply to ATR
During Reactor Outages**
Project Location: **ATR**
Estimate Number: **7B63-C**

Client: **K. F. Hassing**
Prepared By: **E. J. Behunin**
Estimate Type: **Unable to Classify**

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
1.0		<u>Project Development</u>	\$124,000	\$0	\$37,200	30.00%	\$161,200
2.0		<u>Project Management</u>	\$149,000	\$0	\$44,700	30.00%	\$193,700
3.0		<u>Preliminary/Final Design</u>	\$170,000	\$0	\$51,000	30.00%	\$221,000
4.0		<u>AE Support During Construction</u>	\$33,000	\$0	\$9,900	30.00%	\$42,900
5.0		<u>Construction Management</u>	\$188,000	\$0	\$56,400	30.00%	\$244,400
6.0		<u>Execution Phase</u>	\$731,575	\$0	\$219,472	30.00%	\$951,047
6.1		<u>Program Execution</u>	\$731,575	\$0	\$219,472	30.00%	\$951,047
6.1.1		<u>Provide Subcontracted Construction Services</u>	\$719,957	\$0	\$215,987	30.00%	\$935,944
6.1.1.1		<u>General Requirements</u>	\$83,574	\$0	\$25,072	30.00%	\$108,646
6.1.1.1.1		<u>General Contractor</u>	\$32,127	\$0	\$9,638	30.00%	\$41,766
6.1.1.1.2		<u>Earthwork Contractor</u>	\$14,803	\$0	\$4,441	30.00%	\$19,243
6.1.1.1.3		<u>Electrical Contractor</u>	\$20,991	\$0	\$6,297	30.00%	\$27,288
6.1.1.1.4		<u>Piping Contractor</u>	\$15,653	\$0	\$4,696	30.00%	\$20,349
6.1.1.2		<u>Underground Water Pipe Line</u>	\$101,208	\$0	\$30,362	30.00%	\$131,570
6.1.1.3		<u>Electrical</u>	\$33,213	\$0	\$9,964	30.00%	\$43,177
6.1.1.4		<u>Earthwork</u>	\$501,962	\$0	\$150,589	30.00%	\$652,550
6.1.1.4.1		<u>Equipment</u>	\$22,891	\$0	\$6,867	30.00%	\$29,758
6.1.1.4.2		<u>Excavation & Backfill</u>	\$479,071	\$0	\$143,721	30.00%	\$622,792
6.1.2		<u>Provide for 10 CFR 851 Requirements</u>	\$5,201	\$0	\$1,560	30.00%	\$6,761
6.1.3		<u>Subcontractor Training</u>	\$6,418	\$0	\$1,925	30.00%	\$8,343
7.0		<u>Operations Procedures</u>	\$10,052	\$0	\$3,016	30.00%	\$13,068
8.0		<u>Project Transition/Closeout Phase</u>	\$62,000	\$0	\$18,600	30.00%	\$80,600

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Cost Estimating

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Project Summary Report

Project Name: *ATR Water Study/Provide Auxiliary Cooling Water Supply to ATR
During Reactor Outages*
Project Location: *ATR*
Estimate Number: *7B63-C*

Client: *K. F. Hassing*
Prepared By: *E. J. Behunin*
Estimate Type: *Unable to Classify*

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
Total 7B63 ATR Water Study Option C			\$1,467,627	\$0	\$440,288	30.00%	\$1,907,916

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Cost Estimating

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Attachment 4

ATR Water Study – INL Cost Estimate: Dry-Fluid Cooling to Replace Once-Through Air Compressor Cooling Water

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Project Summary Report

Project Name: **ATR Water Study - Option F (Replace Compressor Cooling)**

Project Location: **ATR**
Estimate Number: **7B63-F**

Client: **K. F. Hassing**
Prepared By: **E. J. Behunin**
Estimate Type: **Unable to Classify**

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
1.0	OPC	<u>Project Development</u>	\$155,000	\$0	\$46,500	30.00%	\$201,500
2.0		<u>Project Management</u>	\$178,000	\$0	\$53,400	30.00%	\$231,400
3.0		<u>Preliminary/Final Design</u>	\$176,000	\$0	\$52,800	30.00%	\$228,800
4.0		<u>AE Support During Construction</u>	\$34,000	\$0	\$10,200	30.00%	\$44,200
5.0		<u>Construction Management</u>	\$195,000	\$0	\$58,500	30.00%	\$253,500
6.0		<u>Execution Phase</u>	\$752,086	\$0	\$225,626	30.00%	\$977,712
6.1		.... <u>Program Execution</u>	\$752,086	\$0	\$225,626	30.00%	\$977,712
6.1.1		..... <u>Provide Subcontracted Construction Services</u>	\$740,174	\$0	\$222,052	30.00%	\$962,226
6.1.1.1		..... General Contractor	\$102,050	\$0	\$30,615	30.00%	\$132,665
6.1.1.2		..... Building	\$186,141	\$0	\$55,842	30.00%	\$241,983
6.1.1.3		..... Dry-Fluid System	\$451,983	\$0	\$135,595	30.00%	\$587,578
6.1.1.3.1		..... Piping	\$417,797	\$0	\$125,339	30.00%	\$543,137
6.1.1.3.1.1		..... Piping - General Costs	\$12,610	\$0	\$3,783	30.00%	\$16,393
6.1.1.3.1.2		..... Piping System	\$405,187	\$0	\$121,556	30.00%	\$526,744
6.1.1.3.2		..... Electrical	\$34,185	\$0	\$10,256	30.00%	\$44,441
6.1.1.3.2.1		..... Electrical General Costs	\$5,679	\$0	\$1,704	30.00%	\$7,383
6.1.1.3.2.2		..... Electrical System	\$28,506	\$0	\$8,552	30.00%	\$37,058
6.1.2		..... BEA Support of Construction	\$4,615	\$0	\$1,385	30.00%	\$6,000
6.1.3		..... Provide for 10 CFR 851 Requirements	\$7,297	\$0	\$2,189	30.00%	\$9,486
7.0	OPC	<u>System Operations Training</u>	\$32,121	\$0	\$9,636	30.00%	\$41,758
8.0	OPC	<u>Procedure Revisions</u>	\$46,732	\$0	\$14,020	30.00%	\$60,752
9.0	OPC	<u>System Startup & Testing</u>	\$61,494	\$0	\$18,448	30.00%	\$79,942
10.0	OPC	<u>Project Transition/Closeout Phase</u>	\$84,000	\$0	\$25,200	30.00%	\$109,200

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Cost Estimating

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Project Summary Report

Project Name: **ATR Water Study - Option F (Replace Compressor Cooling)**

Project Location: **ATR**
Estimate Number: **7B63-F**

Client: **K. F. Hassing**
Prepared By: **E. J. Behunin**
Estimate Type: **Unable to Classify**

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
Total		ATR Water Study Option F ATR Dry-fluid Cooling System for Compressors	\$1,714,433	\$0	\$514,330	30.00%	\$2,228,763

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Cost Estimating

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Attachment 5

ATR Water Study – INL Cost Estimate: ATR Sewage Lagoon Options

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Project Summary Report

Project Name: **ATR Water Study - ATR Complex Sewage Lagoon**

Project Location: **ATR**
Estimate Number: **7B63-D**

Client: **K. F. Hassing**
Prepared By: **E. J. Behunin**
Estimate Type: **Unable to classify**

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
1.0	OPC	<u>Project Development</u>	\$26,000	\$0	\$7,800	30.00%	\$33,800
2.0		<u>Project Management</u>	\$41,000	\$0	\$12,300	30.00%	\$53,300
3.0		<u>Preliminary/Final Design</u>	\$41,000	\$0	\$12,300	30.00%	\$53,300
4.0		<u>AE Support During Construction</u>	\$12,000	\$0	\$3,600	30.00%	\$15,600
5.0		<u>Construction Management</u>	\$45,000	\$0	\$13,500	30.00%	\$58,500
6.0		<u>Execution Phase</u>	\$263,378	\$0	\$79,014	30.00%	\$342,392
6.1		.... Program Execution	\$263,378	\$0	\$79,014	30.00%	\$342,392
6.1.1		..... Provide Subcontracted Construction Services	\$260,400	\$0	\$78,120	30.00%	\$338,520
6.1.1.1		..... General Requirements	\$9,305	\$0	\$2,792	30.00%	\$12,097
6.1.1.2		..... General Contractor	\$23,769	\$0	\$7,131	30.00%	\$30,899
6.1.1.3		..... Equipment	\$7,451	\$0	\$2,235	30.00%	\$9,687
6.1.1.4		..... Fence	\$219,875	\$0	\$65,962	30.00%	\$285,837
6.1.2		..... Provide for 10 CFR 851 Requirements	\$2,979	\$0	\$894	30.00%	\$3,872
7.0	OPC	<u>Project Transition/Closeout Phase</u>	\$13,000	\$0	\$3,900	30.00%	\$16,900
Total ATR Water Study -Option D - ATR Complex Sewer Lagoon			\$441,378	\$0	\$132,414	30.00%	\$573,792

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Cost Estimating

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Attachment 6

ATR Water Study – INL Cost Estimate: TRA-609 Air Compressor Cooling Water Discharge

Project Summary Report

Project Name: **ATR Water Study - TRA-609 (Option B)**
Divert Air Compressor Cooling Water from Cold Waste to Sewer
 Project Location: **ATR Complex**
 Estimate Number: **7B63-B**

Client: **K. F. Hassing**
 Prepared By: **E. J. Behunin**
 Estimate Type: **Unable to Classify**

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
1.0	OPC	<u>Project Development</u>	\$3,000	\$0	\$900	30.00%	\$3,900
2.0		<u>Project Management</u>	\$3,000	\$0	\$900	30.00%	\$3,900
3.0		<u>Preliminary/Final Design</u>	\$3,000	\$0	\$900	30.00%	\$3,900
4.0		<u>AE Support During Construction</u>	\$1,000	\$0	\$300	30.00%	\$1,300
5.0		<u>Execution Phase</u>	\$16,097	\$0	\$4,829	30.00%	\$20,926
5.1		... Program Execution	\$16,097	\$0	\$4,829	30.00%	\$20,926
5.1.1		..... BEA Direct Hire Construction (In House)	\$9,119	\$0	\$2,736	30.00%	\$11,854
5.1.1.1		..... General Costs	\$834	\$0	\$250	30.00%	\$1,084
5.1.1.2		..... PVC Plumbing	\$4,059	\$0	\$1,218	30.00%	\$5,277
5.1.1.3		..... Welding Plumbing	\$4,226	\$0	\$1,268	30.00%	\$5,493
5.1.2	OPC	..... Work Orders (WOs)	\$4,559	\$0	\$1,368	30.00%	\$5,927
5.1.2.1	OPC	..... Prepare WO	\$4,559	\$0	\$1,368	30.00%	\$5,927
5.1.3	OPC	..... Operations Procedures	\$2,419	\$0	\$726	30.00%	\$3,145
6.0	OPC	<u>Project Closeout</u>	\$1,000	\$0	\$300	30.00%	\$1,300
Total ATR Water Study Option B (TRA-609)			\$27,097	\$0	\$8,129	30.00%	\$35,226

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Attachment 7

ATR Water Study – INL Cost Estimate: TRA-628 HVAC Control System Modification

Project Summary Report

Project Name: **ATR Water Study - TRA-628 Comfort Control System Mods**

Project Location: **ATR Complex**

Estimate Number: **7B63-A**

Client: **K. F. Hassing**
 Prepared By: **Eric Behunin**
 Estimate Type: **Unable to Classify**

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
1.0	OPC	<u>Project Development</u>	\$21,000	\$0	\$6,300	30.00%	\$27,300
2.0		<u>Project Management</u>	\$19,000	\$0	\$5,700	30.00%	\$24,700
3.0		<u>Preliminary/Final Design</u>	\$18,000	\$0	\$5,400	30.00%	\$23,400
4.0		<u>AE Support During Construction</u>	\$5,000	\$0	\$1,500	30.00%	\$6,500
5.0		<u>Construction Management</u>	\$23,000	\$0	\$6,900	30.00%	\$29,900
6.0		<u>Construction Support</u>	\$45,366	\$0	\$13,610	30.00%	\$58,976
6.1		.... Security/Escort	\$44,596	\$0	\$13,379	30.00%	\$57,974
6.2		.... Outage Coordination	\$771	\$0	\$231	30.00%	\$1,002
7.0		<u>Execution Phase</u>	\$102,241	\$0	\$30,672	30.00%	\$132,913
7.1		.... Program Execution	\$102,241	\$0	\$30,672	30.00%	\$132,913
7.1.1		..... Provide Subcontracted Construction Services	\$99,612	\$0	\$29,884	30.00%	\$129,495
7.1.1.1		..... General Requirements	\$12,832	\$0	\$3,850	30.00%	\$16,681
7.1.1.2		..... Equipment	\$1,935	\$0	\$581	30.00%	\$2,516
7.1.1.3		..... Plumbing	\$21,465	\$0	\$6,439	30.00%	\$27,904
7.1.1.4		..... HVAC Controls	\$63,380	\$0	\$19,014	30.00%	\$82,394
7.1.2		..... Provide for 10 CFR 851 Requirements	\$2,629	\$0	\$789	30.00%	\$3,418
8.0	OPC	<u>Project Transition/Closeout Phase</u>	\$8,000	\$0	\$2,400	30.00%	\$10,400
Total ATR Water Study - Option A (TRA-628 Comfort Control System Mods)			\$241,607	\$0	\$72,482	30.00%	\$314,090

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Cost Estimating

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Attachment 8

ATR Water Study – INL Cost Estimate: Xeriscape Installation at the ATR Complex

Project Summary Report

Project Name: **ATR Water Study - Opt1 Zero-Scape Modifications**

Project Location: **ATR Complex**

Estimate Number: **7B63**

Client: **K. F. Hassing**
 Prepared By: **E. J. Behunin**
 Estimate Type: **Unable to Classify**

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
1.0	OPC	<u>Project Development</u>	\$36,000	\$0	\$10,800	30.00%	\$46,800
2.0		<u>Project Management</u>	\$33,000	\$0	\$9,900	30.00%	\$42,900
3.0		<u>Preliminary/Final Design</u>	\$41,000	\$0	\$12,300	30.00%	\$53,300
4.0		<u>AE Support During Construction</u>	\$8,000	\$0	\$2,400	30.00%	\$10,400
5.0		<u>Construction Management</u>	\$42,000	\$0	\$12,600	30.00%	\$54,600
6.0		<u>Execution Phase</u>	\$206,949	\$0	\$62,085	30.00%	\$269,033
6.1		.... Program Execution	\$191,377	\$0	\$57,413	30.00%	\$248,791
6.1.1		..... Provide Subcontracted Construction Services	\$188,274	\$0	\$56,482	30.00%	\$244,756
6.1.1.1		..... Area #1 - 662 Zone 1	\$69,043	\$0	\$20,713	30.00%	\$89,756
6.1.1.1.1		..... General Costs/Equipment Area #1	\$18,804	\$0	\$5,641	30.00%	\$24,446
6.1.1.1.2		..... Excavation - Area #1	\$11,433	\$0	\$3,430	30.00%	\$14,863
6.1.1.1.3		..... Materials & Install - Area #1	\$38,805	\$0	\$11,642	30.00%	\$50,447
6.1.1.2		..... Area #2 - 662 Zone 2	\$3,845	\$0	\$1,154	30.00%	\$4,999
6.1.1.2.1		..... General Costs Area #2	\$347	\$0	\$104	30.00%	\$452
6.1.1.2.2		..... Excavation Area #2	\$1,383	\$0	\$415	30.00%	\$1,797
6.1.1.2.3		..... Materials & Install Area #2	\$2,115	\$0	\$635	30.00%	\$2,750
6.1.1.3		..... Area #3 - 662 Zone 2&3	\$115,386	\$0	\$34,616	30.00%	\$150,001
6.1.1.3.1		..... General Costs/Equipment Area #3	\$21,438	\$0	\$6,431	30.00%	\$27,870
6.1.1.3.2		..... Excavation Area #3	\$8,575	\$0	\$2,572	30.00%	\$11,147
6.1.1.3.3		..... Materials & Install Area #3	\$85,373	\$0	\$25,612	30.00%	\$110,985
6.1.2		..... Provide for 10 CFR 851 Requirements	\$3,104	\$0	\$931	30.00%	\$4,035
6.2	OPC	.... Project Transition/Closeout Phase	\$15,571	\$0	\$4,671	30.00%	\$20,243
6.2.1	OPC Adjust Preventative Maintenance Package	\$571	\$0	\$171	30.00%	\$743
6.2.2	OPC Project Closeout	\$15,000	\$0	\$4,500	30.00%	\$19,500

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Cost Estimating

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Project Summary Report

Project Name: *ATR Water Study - Opt1 Zero-Scape Modifications*

Client: *K. F. Hassing*
Prepared By: *E. J. Behunin*
Estimate Type: *Unable to Classify*

Project Location: *ATR Complex*
Estimate Number: *7B63*

<u>Level</u>	<u>Group</u>	<u>Description</u>	<u>Estimate Subtotal</u>	<u>Escalation</u>	<u>Management Reserve MR</u>	<u>MR %</u>	<u>TOTAL</u>
Total 7B63 ATR Water Study Option 1 (Landscape)			\$366,949	\$0	\$110,085	30.00%	\$477,033

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Cost Estimating

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